MONTHLY BULLETIN

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

(ENGLISH EDITION)

PUBLISHING and EDITORIAL OFFICES: 231, RUE ROYALE, BRUSSELS.

Yearly prepaid subscription { **Belgium . . . . . 70 Belgas** / **Other countries . . 75 Belgas** } including postage

Price of this single copy: 8 Belgas (not including postage).

(1 Belga = 5 Belgian francs.)

Subscriptions and orders for single copies (January 1931 and later editions) to be addressed to the General Secretary, International Railway Congress Association, 231, rue Royale, Brussels (Belgium).

Orders for copies previous to January 1931 should be addressed to Messrs. Weissenbruch & Co. Ltd., Printers, 49, rue du Poinçon, Brussels.

Advertisements: All communications should be addressed to the Association, **231, rue Royale, Brussels.**

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Vol. XX. — No. 7. July 1938.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[621. 134.2]

A new apparatus for controlling the distribution of steam in the cylinders of a locomotive,

by FLORIAN SERBESCO,
Chief Engineer of the Locomotive Department, Rumanian Railways.

Good control of the distribution of steam in the driving mechanism of a locomotive results directly in even running of the engine, and also in a minimum of hammer blow in the driving mechanism, as well as on the permanent way.

Wear and tear of the locomotive and of the track is decreased, whilst the efficiency of the locomotive is increased.

It is for these reasons that all Railway Administrations pay a good deal of attention to the regulation of steam distribution in locomotives.

To achieve steady running of a locomotive, it is desirable that the distribution of steam in its cylinders should be arranged in such a way that, on each face of the driving pistons, the pressure, for similar positions of the driving piston, should be the same.

If p is the pressure of steam on the rear face of the right-hand cylinder driving piston, when this piston has covered a distance d from the back dead-centre, then the same pressure p must be found on the front surface of the piston when this piston has covered the same distance d from the forward dead-centre.

These conditions must apply equally for pressures in the left-hand cylinder.

This ideal regulation can be obtained, in practice, only with poppet-valve locomotives. It cannot be applied to slide-valve locomotives for the following reasons :

1. The steam admission ports in the cylinders differ between front and rear for similar positions of the driving piston. These differences are the more marked that the locomotives have shorter connecting rods in comparison with the radius of the crank, and when the valve eccentric rod is shorter in comparison with the radius of eccentricity.

Figure 1 gives elliptic diagrams for the forward running of a *Pacific* locomotive of the Rumanian Railways. It will be seen that with a cut-off $\varepsilon = 20$ %, the admission of steam in the rear part of the inside cylinder proceeds until the driving piston has covered 18.5 % of its stroke, whilst for the front part, steam is admitt-

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Forward running.

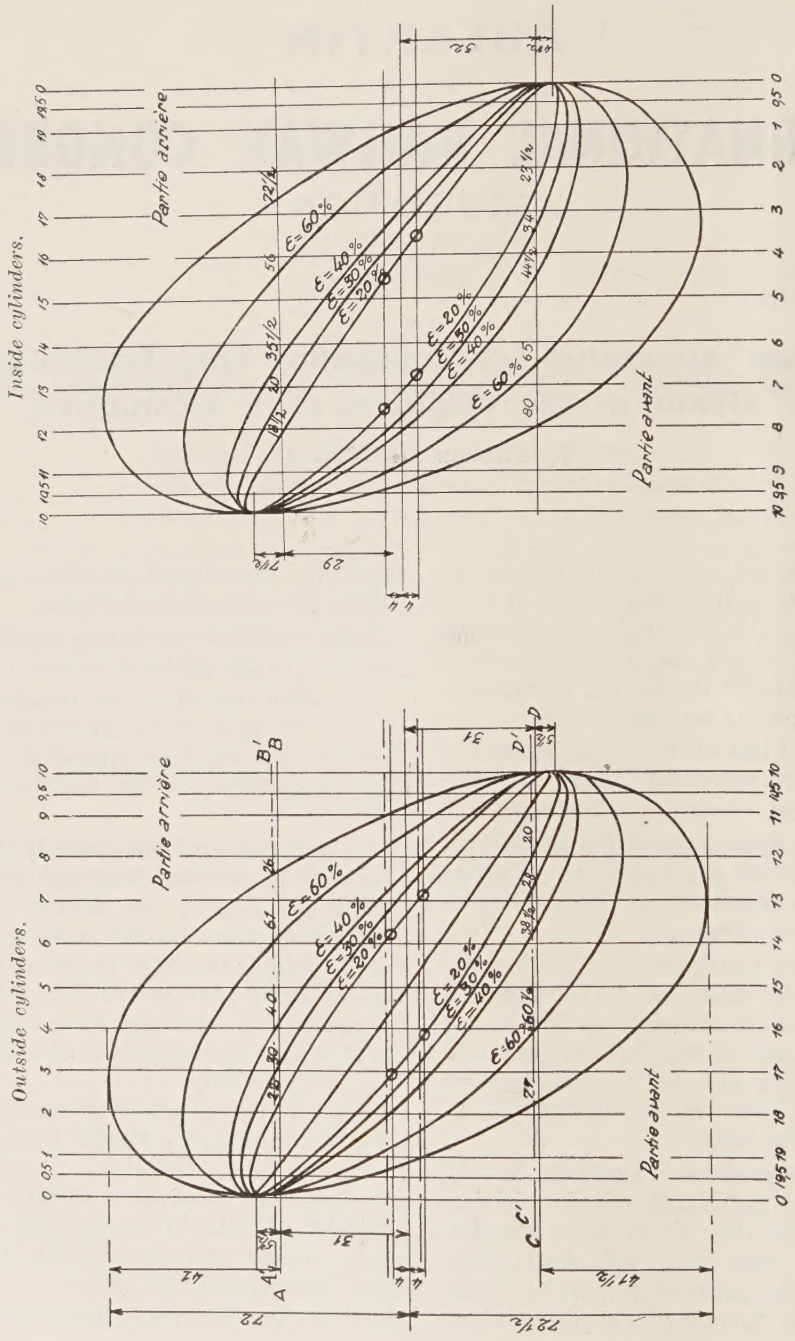


Fig. 1.

Note. — Partie arrière (avant) = front (rear) part.

ed for a stroke of 23.5 % (outside admission).

The other phases of the distribution (expansion, compression, etc.) have also periods which vary between front and rear.

For the outside cylinders, the difference between front and rear is smaller, because the outside connecting rod is fairly long, and the admission is effected inside.

It will even be seen that, to be able to realise pressures which are as nearly equal as possible, there have been provided for the inside cylinders, widely different linear leads, 4.5 mm. (0.177 in.) for the front and 7.5 mm. (0.295 in.) for the rear.

Thus there are, even for the dead centres of the inside piston, widely different admission port openings.

As regards the maximum size of openings for these parts, these also differ greatly, 6 mm. (0.236 in.) for the front part, and 9 mm. (0.354 in.) for the rear part.

For the outside cylinders of this locomotive, as for the majority of two-cylinder locomotives, equal linear leads (5.5 mm. = 0.217 in.) have been given, taking into account that with this setting there will not be too large differences between the front and rear pressures.

2. The different cooling of the front part compared with that of the rear part, also produces variations on the two faces.

A good thermic insulation of the cylinders is an almost perfect remedy for this.

3. The last and most important of all causes of defects in the steam distribution of slide-valve or poppet-valve locomotives is the practical impossibility of having the different parts of the valve gear exactly in accordance with the drawings. This drawback is evidenced mainly on poppet-valve locomotives, which are very much affected should the cams be forced out of position.

The torsion of the control rods, produced by the inertia of moving parts, also gives rise to defects in this type of distribution.

As an example, the case may be quoted of a poppet-valve locomotive which, although well regulated at the builder's works, has been in service for several months with the valves on the left-hand side badly out.

Figure 2 shows the diagrams obtained with the pressure indicators during control of the regulation, and figure 3 shows the diagrams obtained after accurate setting of the valve gear. It will be seen that the two latter diagrams, front and rear, are almost identical, denoting that the profile of the cams has been well designed, but that their setting was defective.

To show the great influence which a slight derangement has on the steam distribution, let us suppose that the slide valve of a locomotive is displaced one millimetre from its normal position towards the front. The admission and exhaust laps are modified by one millimetre, but in an inverse sense for the rear part compared with the front part.

The elliptic diagram for the rear part of the ouside cylinder (fig. 1) is modified by the fact that the line AB which represents the admission lap is displaced one millimetre upwards, to A'B', whilst the line CD, which represents the admission lap for the front parts, moves to C'D'.

It will be seen that the admission passages for the rear part are decreased by one millimetre, which is a considerable amount by comparison with the normal values, which are already very small — a few millimetres — particularly with small admissions.

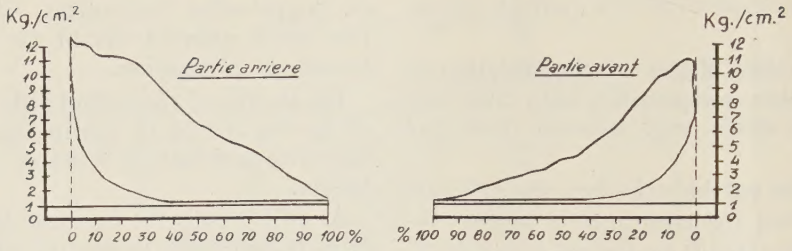


Fig. 2. — Pressure diagrams for poppet-valve engine 230.507, left-hand side cylinder, before adjusting the valve gear; speed 50 km. (31 miles) per hour; cut-off, 15 %.

The passages in the front part are, contrarily, increased by one millimetre. Further, the period of admission for the rear part is also decreased, whilst the admission period for the front part is increased.

A much greater quantity of steam will enter the mechanism by the front part, which will upset the valve gear.

It will thus be seen that the greatest attention must be paid to the regulation of the valve gear, since very small displacements of the slide valve can have a great influence on the regulation.

We have seen that, for piston-valve distribution, the setting of the valve gear in the shops should be carried out with due regard, in each class of locomotive, to the length of the connecting rod.

If the standards which bear relation to the definite length of the connecting rod (linear leads decided upon, equal maximum sizes of ports, geometrically equal admissions, etc.) are not well determined, or if small errors of erection are allowed, or even if the parts of the valve gear are not exactly made, there will be faults in the distribution.

The only way of recognising a defective valve gear is to set the locomotive to work, and to listen to the blast.

The pressure indicators, whilst they are able to give valuable data, are seldom used in view of the difficulty of mounting them.

If the blast is regular, it can be concluded that the same amounts of steam are entering each part of the cylinder.

The practical impossibility of recognising a good distribution with certainty from listening to the blast has led us to construct a device, for which a patent has

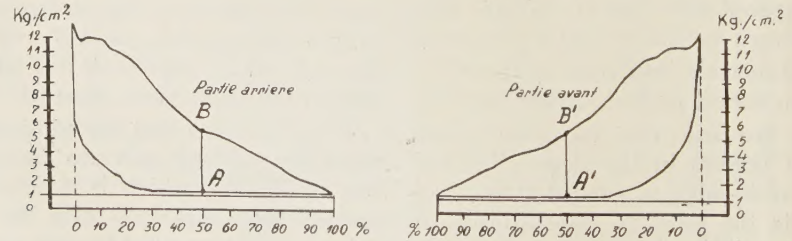


Fig. 3. — Pressure diagrams for poppet-valve engine 230.507, left-hand side cylinder, after adjusting the valve gear; speed, 50 km. per hour; cut-off, 15 %.

been taken out, which measures the pressure of expansion in the right- and left-hand side cylinders, at the front and rear, when the driving pistons have covered the same distance from the respective dead-centres.

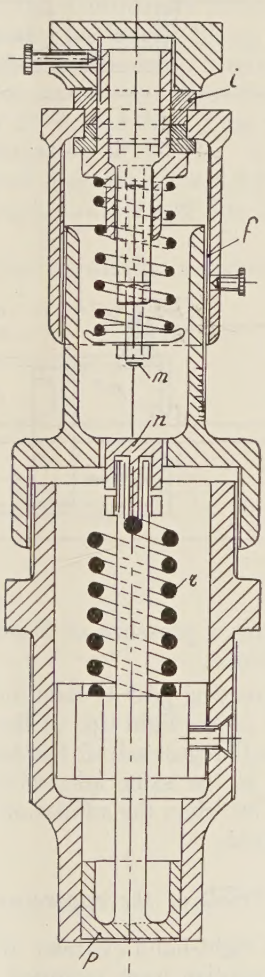


Fig. 4.

If the pressures are equal, it can be said the quantities of steam are equal, because the volumes are equal and the temperatures are equal (the cylinders being well insulated).

We can thus say that the steam diagrams in figure 3 represent a good distribution, since the pressures AB and A'B' at half-stroke are equal.

By verifying various steam diagrams of well-regulated locomotives, we found equality of pressure for the average position of the driving pistons.

Description of the distribution control device.

The arrangement consists of four indicator devices as shewn in the drawing, figure 4. These are connected to the four steam admission passages for the driving cylinders (fig. 5).

The steam pressure works on the small piston *p* of the indicator apparatus, held by the calibrated spring *r*.

In the cap of the device is situated a part *m* which is insulated from the body of the indicator by an insulating bush *i*. This part *m* can be brought up to the end *n* of the rod of the small piston, by screwing the cap down on the threaded part *f*.

The parts *m* and *n* are brought into contact by the pressure exerted on the piston. The apparatus is graduated to determine the pressure which produces contact for a given distance between *m* and *n*.

Each indicator is placed in an electrical circuit, energised by an electric battery S (figure 5).

This circuit is broken when there is no pressure in the indicators; it is also broken by the contact-breaker *c-k*. This contact-breaker closes the circuit when the driving piston is at half stroke.

In each circuit there is an electric bulb which lights when the circuit is closed.

By bringing the contacts *m* and *n* to-

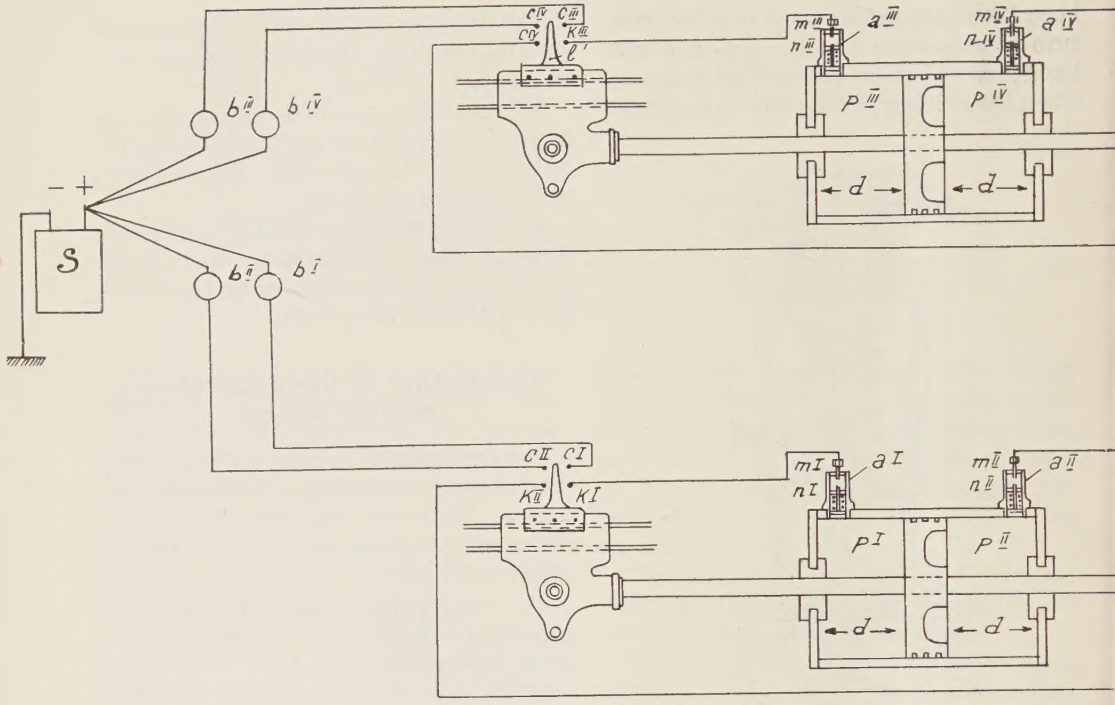


Fig. 5.

gether until the circuit is closed, the pressure in the cylinder, when the piston is at the middle of its stroke, can be found.

The pressures in the cylinders should be equal if the valve gear is well set.

The difficulty of reading the pressures on each indicator when the locomotive is in service, has led us to adopt the following arrangement :

The distance between m and n is regulated first of all to correspond to a predetermined pressure, say 3 atmospheres.

The locomotive being in service, the reversing gear is placed at the dead-centre, and is then continuously displaced, whilst increasing the admission until an electric lamp lights up.

We thus find what the admission is which gives a pressure of 3 atmospheres at mid-stroke.

The reversing gear is then moved until the other lamps light up. If the distribution is well regulated all the lamps must light up at the same admission, and all must go out when the admission is slightly decreased.

Trials of the apparatus.

On the right-hand cylinder of a piston-valve locomotive were mounted two indicator devices for registering steam diagrams. On the same cylinder the apparatus described above was fitted.

The valve was displaced until the two electric lamps lit up at the same admission, 29 % front and rear.

On a planimetered diagram this showed 6.4 cm^2 for the rear part and 6.6 cm^2 for the front part.

Starting from this valve position, which could be regarded as accurate, the valve was moved half a millimetre forward. The electric lamps no longer lit up for the same admission. The lamp corresponding to the front part lit the first for an admission of 28 %, and that of the rear part for an admission of 30 %. A further planimetered diagram showed 6.2 cm^2 for the rear part, and 6.8 cm^2 for the front part.

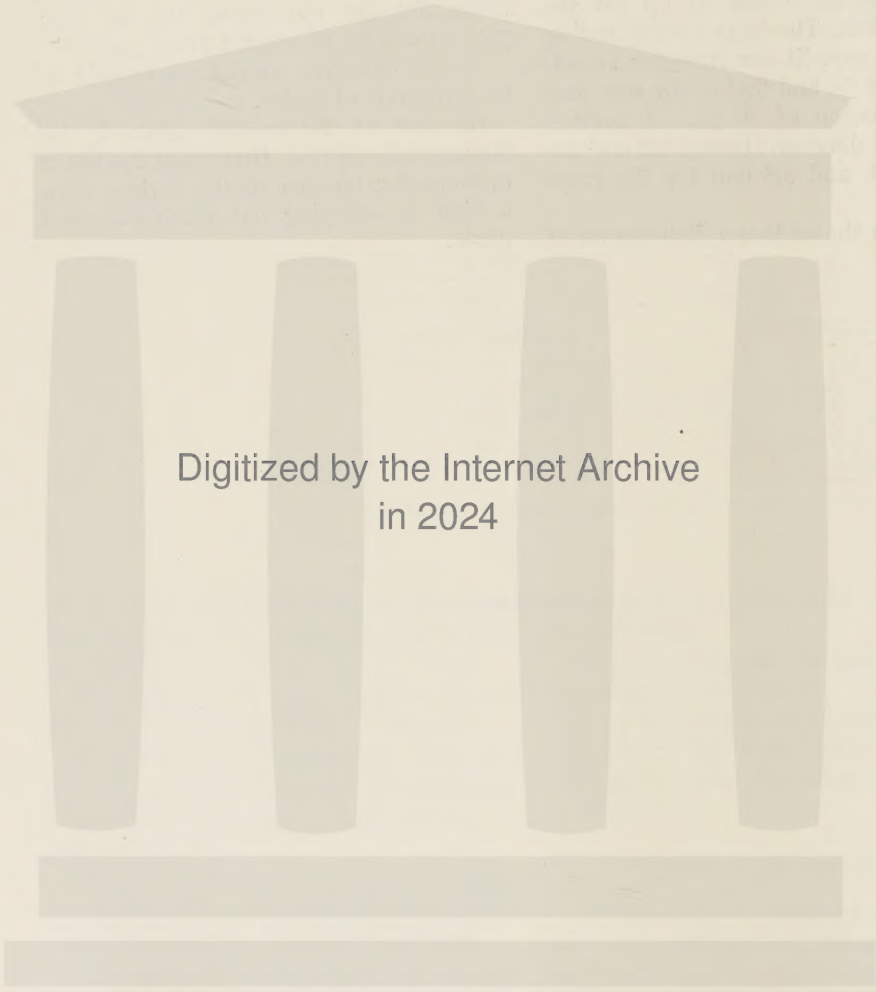
It was then shown that a disturbance of the steam distribution had commenced.

Following this the piston-valve was set back 2 mm. This time the rear part lamp lit up first for an admission of 28 %, whilst the front part lamp lit up at 34 %.

Planimetered diagrams being again taken, 7.3 cm^2 was shewn for the rear part, and 6.1 cm^2 for the front part.

The distribution could then be said to be quite out of order.

In view of the results obtained, the Management of the Rumanian Railways purchased a number of the devices, with a view to carrying out more extended trials.



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[656. 234]

Tickets,

Continued (*)

by Lionel WIENER,
Professor at the University of Brussels.

PART D.

PECUNIARY ASPECT OF THE TICKET.

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ACTUAL PAYMENT.

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Change of fares.
2. Taxes and dues.
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* * *

CHAPTER VIII.

TIME OF PAYMENT.

Tickets are generally bought at the booking office on starting the journey. They can also be bought in advance, or after the journey has begun. Payment on arrival is exceptional.

A. PAYMENT ON STARTING.

There is no need to deal with tickets bought in this way.

(*) See *Bulletin of the Railway Congress*, March 1938, p. 217, and May 1938, p. 473.

B. PAYMENT IN ADVANCE.

Various kinds of tickets can be paid for in advance, from single units (fig. 300) to series of various kinds.

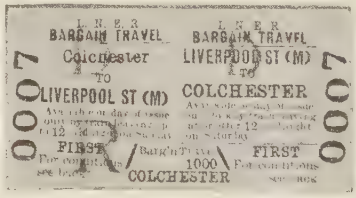
This gives the Company certain advantages. Advance sales save space in the booking office, which facilitates the service. They obviate the necessity of finding change, which is a boon on metropolitan lines, as this enables the booking clerk to attend to the passengers' needs with considerably more celerity.

Large sums of money may be involved in stocks of tickets, and this money lies idle.

In order to further advance sellings, the tickets are often sold at reduced rates. Sometimes, particularly in the case of road services, the reverse occurs and tickets are sold in advance at the normal rates and in the cars, at an enhanced one.

Fig. 300. — Pre-paid ticket. (Red. 3/4) — French *Est Rys.* — Control stub detached at departure station.

We believe the *Great Eastern Ry.* was the first to sell, in 1905, packets of Edmondson tickets, one of which was valid for each day of the week. The *Midland Ry.* and others followed suit, and extended the system to workmen's tickets as



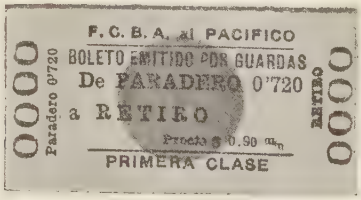


Fig. 301. — Travel agency ticket *(Maison de France).* (Red. 4/5) — *P. O.-Midi Ry.* — 32.5 % tax included — Validity by special train only, shown by overprint.

Fig. 302. — Bargain travel ticket. (Red. 4/5) — *London and North Eastern Ry.*

Fig. 303. — Ticket issued on the train to passenger boarding the train at a halt. (Red. 4/5) — *Buenos Ayres and Pacific Ry.*

well. At the present time, British railways sell bulk tickets of a fairly long period of validity at reduced rates to commercial travellers and others (figs. 302, 304 and 305). Recognised clubs can also buy them and retail them to their members for use as required in connection with their sporting or social activities (1).

The most usual example of pre-paid tickets are season and multi-journey tickets. In fact, they are only obtainable in this way, even though the holder may be allowed to pay for them by deferred payments (fig. 307).

Tickets sold by private agencies (figs. *178*, 301) do not differ from those sold at the booking office except for showing the name of the Agency (see Part G); they only need stamping to become valid.

We have divided this very complicated category of tickets as follows :

1. Tickets for an indefinite number of journeys, such as season tickets sold to passengers, and free passes.

2. Tickets for a definite number of journeys, multi-journey tickets (American trip-passes), free or otherwise.

3. Tickets for two return journeys. — These will be dealt with immediately af-

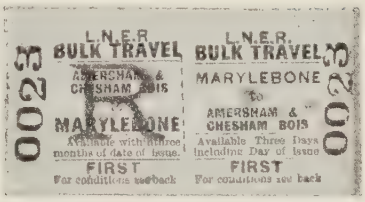


Fig. 304. — Bulk travel ticket. (Red. 4/5) — *London and North Eastern Ry.* — Return portion overprinted with large letter R.

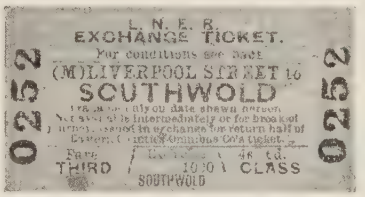


Fig. 305. — Exchange ticket issued against distance coupons. (Red. 4/5) — Same Company.

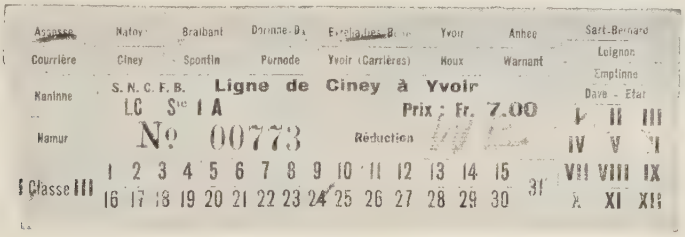


Fig. 306. — Paper ticket issued on the train. (Red. 3/4) — *Belgian National Rys. Co.* — List of places served, of classes, of dates and months.

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(1) As the *L. P. T. B.* to the « Nelsons's Athletic Association »; the « Victoria Athletic Association », etc.;
the *Southern Ry.* to the « Athletic Club »;
the *Bex-Gryon-Villars Ry.* to the « Ski Club » (valid on Saturdays or Sundays);
the *Buenos Ayres and Pacific Ry.* (Argentine), to the « Regatta Club »; the « Golf Club »;
in *Austria*, to the « Touristen Verband ».

ter ordinary return tickets. Single-journey permits and privilege tickets will be examined in the Chapter dealing with reduced rates.

ABONNEMENT N°
M
VERSEMENT
Somme à percevoir
COUPON MENSUEL
POUR
JANVIER 1924
L'Ingénieur en Chef de l'Exploitation,
La durée de validité d'un coupon mensuel court du 6 du mois pour lequel il est établi jusqu'au 4 du mois suivant.
AVIS IMPORTANT
Ce coupon doit être présenté adhérent à la couverture portant le même numéro, sinon il sera retenu et l'abonné sera considéré comme un voyageur sans billet.

Fig. 307. — Payment coupon for monthly season ticket. (Red. 3/4) — French *Nord Ry.*

1. Seasons and free passes.

Season tickets are available

Between any two places;
Over one or several zones;
On all the lines of a division or group of lines;
Over the whole system;
For through trips on one or several adjoining systems.

The geographical availability of the season ticket is usually added by hand.

On suburban lines, they are sometimes printed with lists of places, those between which they are valid being shown by perforation. On road transport tickets, stage numbers are often used instead. Reductions of from 10 to 25 and even 50 % are awarded on certain other lines branching off those on which their ticket is available, to season ticket holders.

Seasons are also issued for non-consecutive days, such as :

Five Sundays following;
Five days of one month;
One day a week during a certain number of weeks.

The PERIOD OF AVAILABILITY also varies. It may be :

One day. — This is exceptional on railway lines, less so on tramway or bus services;
Five consecutive days. — This system was started in Belgium;
The working week;
Weekly;
Fortnightly or two weeks;
Monthly (1);
Quarterly;
Semi-annual;
Annual.

Different tickets are used in these different categories. The dates are filled in by hand, stamped on, or shown by perforation or clipping. Period-scale stub tickets are also used. On the *Pennsylvania R. R.*, each month of the year, and on the *Pacific Electric Ry.*, every week for several months is listed (fig. 308). The remaining length of the stub gives some idea of its availability.

The date is usually added when the ticket is bought. However, some season

(1) In Belgium, the days of the month are shown on the outer edges of the card, and a triangular slot is nipped out of it to indicate which of them apply.

tickets bear lists of the months and days of the month among which it is easy to indicate those that apply.

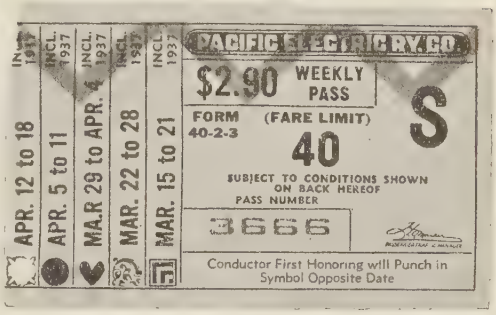
IDENTIFICATION OF THE HOLDER. — Season tickets often have a photograph of the holder. He should always sign the ticket, and in the States, his signature often follows a statement that he undertakes « on his honour » not to lend the ticket to anyone else.

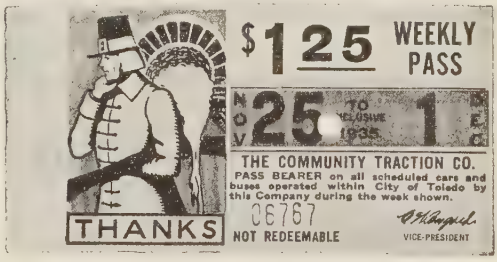
THE PRICE OF THE SEASON TICKET is usually added by hand. It can often be paid for in instalments. Basic strip coupon fare rates are only used for multi-trip cards (1).

Certain Companies issue season ticket stamps which are sold in advance and affixed when the card is to be used (fig. 406).

Season tickets for road transport. — American passes. — On tramway and bus services, season tickets raise even more important problems than they do on railways, for they can, if not carefully studied, unsettle traffic conditions.

In the States, besides straight fares for which no tickets are given, the Companies issue trip cards or passes [season tickets (figs. 308 to 311), tokens bought in advance at a rebate (figs. *140*, 408)], free transfers, and others for which a supplement must be paid in the first car, in the second or in both. Passes, tokens and transfers delivered during the first ride and available for another, are all pre-paid. Their interdependence must, however, be stressed as they react upon each other through the public, thus making it possible for the traffic to be gauged more easily and quicker than would




$1 25 WEEKLY PASS
NOV 25 TO 1
THE COMMUNITY TRACTION CO.
PASS BEARER on all scheduled cars and buses operated within City of Toledo by this Company during the week shown.
C6767
NOT REDEEMABLE
VICE-PRESIDENT
THANKS

Weekly passes. (Red. 3/4).

Fig. 308. — Week scale stub. with distinguishing date symbols, to be punched by conductor — *Pacific Electric Ry. Co.*

Figs. 309 and 310. — Chromo-lithograph passes — *Los Angeles Ry.* and *The Community Traction Co.* — With safety background — Subject of illustration relates to the period of validity.

(1) *Belgian National Light Rys. Co.* — Workmen's 7 outward and return trips.

otherwise be possible. To illustrate this, we shall quote a couple of instances selected, so that they should be comparable, from the *St. Louis Public Service Co.* (1) and the *Kansas City* system whose rates were, at first, identical : a straight 10-cent cash fare and 4 tokens for 35 cents (8 3/4 cts. per trip).

In August 1929, the single fare was increased at St. Louis, from 8 to 10 cents and a weekly 90-cent multi-trip (commutation) ticket was introduced; this entitled the holder to 12 trips, and to additional trips at 5 cents each (fig. 344). The fact that a number of holders did not make use of the latter privilege was clearly demonstrated when the price was advanced from 90 cents to $ 1 in December 1929. Marginal purchasers no longer bought the passes whose number fell by 20 000 a week. This was offset, however, by an increased number of journeys at the full 10-cent fare.

The crisis also affected the traffic, and there was a further reduction in the number of tickets sold per week, which coincided exactly with short-time working in the shops.

In August 1932, the price of the tokens was reduced to 4 for 35 cents, giving an 8 3/4 cent fare, though the ordinary 10-cent fare was retained.

So as to develop slack hour traffic, various kinds of special tickets were introduced : scholars' tickets (2), sunday passes (3) and shoppers' tickets, which we will deal with elsewhere, but their effect on ordinary runs concerns us here.

The influence of scholars' tickets, only 2 400 of which were sold per week, was negligible. When the price of Sunday passes was increased, the number sold fell off, but this was made good by a corresponding increase in full-fare journeys.

Whereas 26 p. c. of the receipts were earned between 10 a. m. and 4 p. m., the introduction of shoppers' tickets (return ticket at the ordinary single fare) altered the time at which 5,000 ordinary passengers travelled. Taking this into account, the increase would be 126,300 instead of 88,300, or 38,000 journeys more a day, 62 p. c. of the passengers using the new tickets. Of the 40,000 who formerly used them, 14,000 would have paid the full 10-cent fare and 26,000 the 8 3/4-cent token fare. The average loss of 4 cents per journey on the former regular passengers was more than offset by the 38,000 new passengers at 5 cents. On the debit side must be included the operating costs of a few additional cars which had to be run.

In *Kansas City*, the 10-cent straight fare and 8 3/4 token fare (4 tokens for 35 cents) were found to be too high when the crisis began. Attempts were made to reduce the fares and increase the traffic so as to compensate the resulting loss of receipts (4).

On the 30th July, 1933, weekly dollar passes were introduced. Had they been priced higher, they would not have attracted the passengers who travelled but 12 times a week; for example, had the

(1) Taken from a most interesting paper by Mr. Georges E. Owen, Research Director, *St. Louis Public Service Co.*, kindly sent us by the *Globe Ticket Co.*, of Philadelphia.

(2) Sold at 70 cents for 10 journeys, the unit price of 7 cents being between the 9-cent ordinary fare and the 5-cent shopper's fare.

(3) The fare was increased from 25 to 30 cents with a 5-cent refund when the expired ticket was handed in.

(4) From a paper by Mr. F. G. Buffe, Vice-President, also sent us by the *Globe Ticket Co.*, of Philadelphia.

pass been sold at $ 1.25, each trip would have cost 10.4 cents, which would have been more than the cost of an ordinary ticket. Besides this, occasional passengers travelling 8 or 9 times a week would have been lost; this justified the price being fixed at $ 1. In five weeks, 45,000 passes were being sold instead of 25,000, while the operating costs only increased by $ 11,700 a month (1).

The average increase in receipts was 31.5 p. c.; it was 35 p. c. for working days, and taking the seasons into account, 46 p. c. At the same time, token sales decreased by 58 p. c. and ordinary 10-cent tickets, by 7 p. c.

Taking all these results into account, the passes were responsible for 43 p. c. of the gross receipts.

The average receipt per passenger had, however, fallen from 9.3 to 6.79 cents. As a matter of fact 33.8 trips per week were made on passes. Deducting the 37 p. c. of transfer journeys, there remained 22 pass trips and the final average receipt worked out at 4.67 cents per journey. Actually, the results were slightly better as some seven of the journeys were short and would not have been made without a pass. It is more accurate to consider that out of 33 pass trips, there are 15 cash fare trips, 8 transfers and some ten short rides. Taken as a whole, the total gross receipts increased by 6.8 p. c.

Passes tend to stabilise receipts which no longer fall off as much in bad weather, but also do not increase to the same extent on holidays and special occasions. The number of journeys certainly increases, but at the expense of the average price of transport. This falls gradually as the public gets to use passes to a greater extent, until the situation tends to show a deficit, when adjustments have to be made.

On the 1st January, 1934, the price of the passes was accordingly increased to $ 1.10. The sales declined immediately and fell in one week from 45,800 to 39,600, the loss of 6,200 being attributable to those passengers who travelled but 11 or 12 times a week. On the other hand, the sale of tokens brought in $ 29,000 instead of $ 21,000, and the 10-cent rides, $ 2,400 more, while the amount received for the passes also increased by $ 5,000. Average receipts per passenger increased from 6.79 to 7.14 cents.

Although the number of passes sold remained constant (39,300 per week in June, 1935), the number of journeys on each pass increased progressively and at the same period had reached 121,000. This again reduced the average receipts per journey, which no longer corresponded to the rebate sale of tokens. A further adjustment was due and the price of passes was again increased, this time to $ 1.25.

The results were similar to those experienced after the first increase, but on a less extensive scale. The average receipts per journey rose from 6.54 to 6.92 cents and the sale of passes increased by $ 1,100 a week.

It will be seen that a time comes when

---

(1) Made up as follows :

	Dollars.
Additional car-miles, resulting in increased power consumption and maintenance	2,520
Additional staff required, on account of increased car-miles	2,295
Do. reduction in speed	1,348
Higher current consumption, due to heavier loads and more frequent stops	1,774
More accidents and damages, due to the greater number of passengers	2,750
Cost of printing and issuing the passes	1,000

the cost price that can be charged for a pass reaches a maximum limit, while the average takings per trip fall to a minimum amount which no further rise in the price of the pass could increase.

SPECIAL CATEGORIES (CLASSES) OF SEASON TICKETS. — Railway Companies issue season tickets at reduced rates to certain categories of passengers :

Members of a family.
Members of large families, including or excluding servants (1).
Children travelling alone or not.
Scholars or students.
Persons attending industrial and other schools (2).

Military.
Crippled or disabled soldiers, different rates applying according to the extent of their disabilities.

Tourists (3).
Excursionists, sometimes in a given zone (4), with or without additional reductions for large families (1).

Commercial travellers.
Company's employees (privilege tickets).
Workmen.
Apprentices (5).

Road transport Companies do not cater for as many different classes, but the following are usual :

Children (6).
Military.
Cripples or blind.
Company's employees.
Scholars or students.
Workmen.

In America, however, the following are also found :

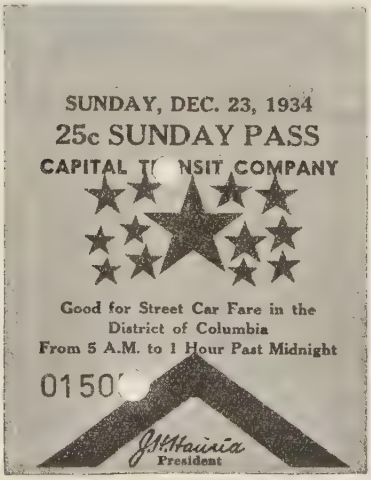
Weekly passes,
Sunday passes,
Sunday holiday passes,
Shoppers' passes,
Shopper-theatre weekly passes.

besides special kinds of season tickets (7).

AMERICAN SUNDAY OR WEEK-END SEASONS. — Sunday passes (fig. 312) and Week-end passes were introduced in order to increase the traffic on slack days (8). The former are available for 24 hours, from 2 a. m. on Sunday morning to 2 a. m. on Monday. The latter are valid from 1 p. m. on Saturday till 2 a. m. on Monday. The holder is generally allowed to take two children under 12 with him free.

SHOPPERS' TICKETS. — In order to get better utilisation of the stock during the slack hours between 10.0 a. m. and 4.0 p. m., the Receiver, Mr. Henry W. Kiel, former Mayor of St. Louis, introduced reduced-fare Shoppers' tickets on the 10th July, 1935. As this proved successful, season tickets were introduced for an indefinite number of journeys between

(1) In France.
(2) Holland.
(3) *New South Wales Government Rys.*
(4) England, France.
(5) *New Zealand Govt. Rys., Pennsylvania R. R.*
(6) Under 7 in France, under 10 in Russia, under 12 in America and under 14 in England.
(7) Scholars, Company's employees. Other Systems also issue trip cards (multi-journey tickets).
(8) Printed on the same card as ordinary passes with the same byelaws, safety and checking safeguards.



Limited-period passes (Red. 3/4).

Fig. 311. — Shopper's pass — *Rochester City Trolley and Bus Lines* — Printed with date — Punching spaces for 5 journeys.

Fig. 312. — Sunday all-day ticket with distinctive mark.

the same hours; the price was the same as for 6 straight rides, it being estimated that occasional passengers average 3 return trips a week (fig. 311) (1).

(1) *Washington Rapid Transit Co.*

In St. Louis, 26 p. c. of the passengers travelled between 10 a. m. and 4 p. m. Taking the time some of these travelled into account, some 88,300 passengers could be counted upon. Actually, there were 126,300, or 38,000 trips more than had been anticipated, which was due to the new passes.

About 72 p. c. of the daily passengers used them. Some 40,000 (including 14,000 at 10 cents and 26,000 at 8 3/4 cents per trip) were in fact affected. The loss in receipts on the former was 4 cents (as the fare paid was only 5 cents) and on the latter, 3 3/4 cents, which was less than the increase in the receipts due to the 38,000 new passengers.

The availability of these tickets was extended to the slack hours of the evening by making them valid, under the name of Shopper-Theatre Passes, after 6.30 p. m. as well.

PARTIES SEASON TICKETS. — The price decreases as the number of persons increases. These tickets are issued to :

Members of the same family;
Associates of any undertaking.

SPECIAL SEASON TICKETS. — Many Companies issue special seasons for urban or suburban traffic.

Some of them issue seasons at lower rates to women. In Germany, an increased rate applies to seasons for the « Eilzuge » (expresses).

There is less variety in the road transport seasons, large numbers of which are issued.

Various kinds of season tickets. — Early seasons or passes were generally coins or tokens, and usually round. They were often made of bronze for short-period tickets, of silver for longer periods, and sometimes of gold or of ivory when available for a year or more *(fig. 40)*. These seasons and passes were mostly used in England and by British Companies abroad.

To make them more convenient, they were often provided with a link to hang them on the watch chain *(figs. 146 and 147)*. But cheaper tokens, which remained in use until quite recently, have since replaced them *(figs. 132 and 133)*.

Folders, Edmondson tickets, and cards are all used for season tickets

(a) SEASONS WITH FOLDING COVER. — The ticket proper often consists of a sheet of paper giving the necessary information, stuck inside a sheet of folding cardboard covered with leather, cloth, or percalin.

Fig. 313. — Season ticket. (Red. 3/4) — *London Chatham and Dover Ry.* — *Metropolitan Extension* — Leather cover with gold embossed lettering and the Company's arms.

English seasons standard sizes are 3 5/8" × 2 3/4" (figs. *46* and 313), while the South American are 4" × 3" (105 by 75 mm.). On the Continent, they are generally larger and less convenient. Those which are issued free only differ from the others by the text *(fig. 46* : Senator's free pass).

There is considerable variety amongst seasons or temporary permits issued on special occasions such as the sessions of the *International Railway Congress Association*. These passes are generally available for two months and have the unique characteristic of being valid on all the Railways affiliated to the Association. This includes a journey to the country where the Congress is being held, free travel over all the lines of the country, and the return journey anywhere.

Figure 314 illustrates the latest Congress pass issued for the 1937 Paris session. It includes a map of the principal railways of Europe and another of the

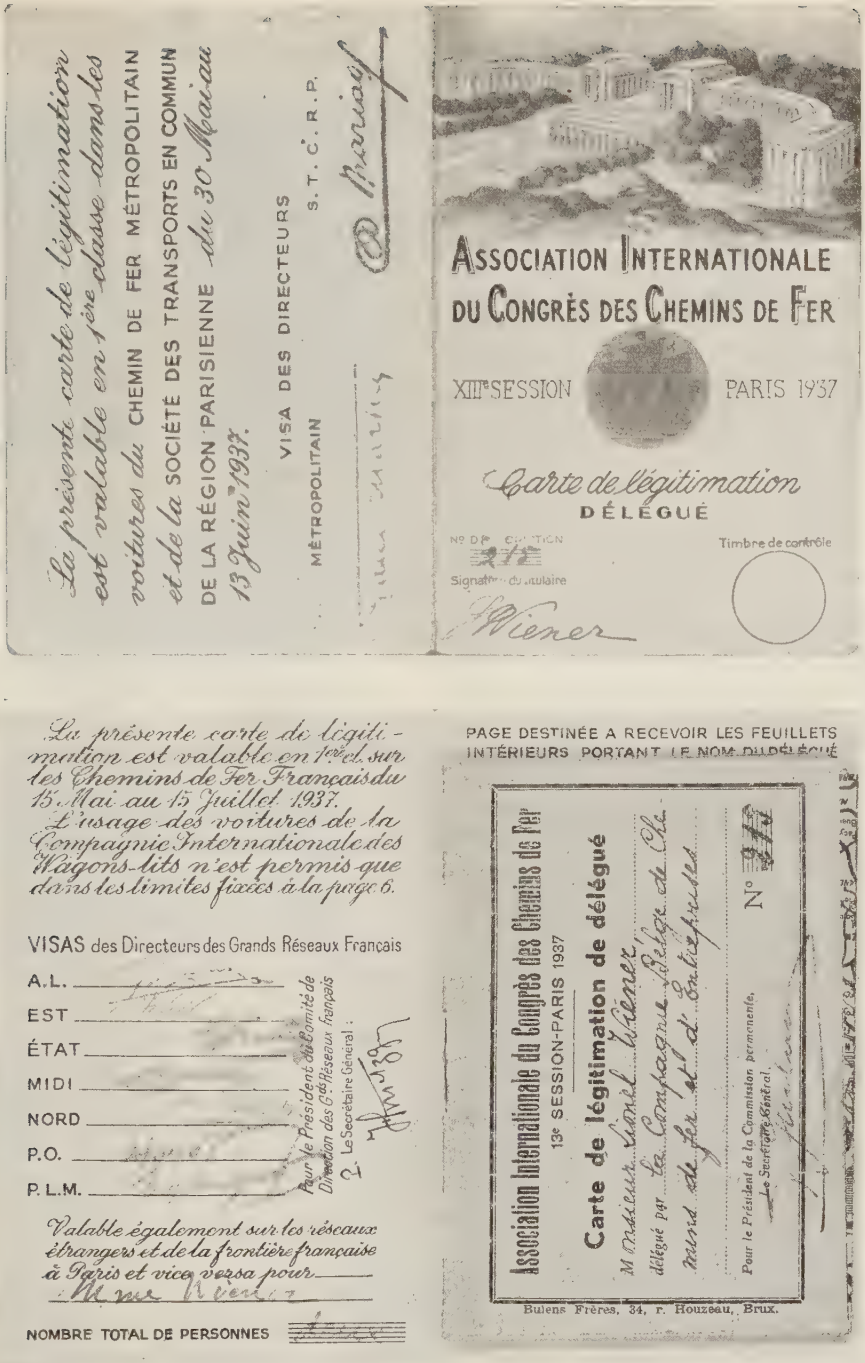

La présente carte de légitimation est valable en 1ère classe dans les voitures du CHEMIN DE FER MÉTROPOLITAIN et de la SOCIÉTÉ DES TRANSPORTS EN COMMUN DE LA RÉGION PARISIENNE du 30 Mai au 13 Juin 1937.
VISA DES DIRECTEURS
S. T. C. R. P.
MÉTROPOLITAIN
ASSOCIATION INTERNATIONALE DU CONGRÈS DES CHEMINS DE FER
XIIIe SESSION
PARIS 1937
Carte de légitimation
DÉLÉGUÉ
Timbre de contrôle
Signature du titulaire
La présente carte de légitimation est valable en 1re cl. sur les Chemins de Fer Français du 15 Mai au 15 Juillet 1937.
L'usage des voitures de la Compagnie Internationale des Wagons-Lits n'est permis que dans les limites fixées à la page 6.
VISAS des Directeurs des Grands Réseaux Français
A.L.
EST
ÉTAT
MIDI
NORD
P.O.
P.L.M.
Pour le Président du Comité de Direction des Gds Réseaux Français :
Le Secrétaire Général :
Valable également sur les réseaux étrangers et de la frontière française à Paris et vice versa pour
NOMBRE TOTAL DE PERSONNES
PAGE DESTINÉE A RECEVOIR LES FEUILLETS INTÉRIEURS PORTANT LE NOM DU DÉLÉGUÉ
Association Internationale du Congrès des Chemins de Fer
13e SESSION-PARIS 1937
Carte de légitimation de délégué
délégué par
Pour le Président de la Commission permanente,
Le Secrétaire Général,
N°
Bulens Frères, 34, r. Houzeau, Brux.

Fig. 314. — Cover and first pages of a free pass booklet (Red. 3/4) — Issued to Delegates to the International Railway Congress — Space for official control stamp — Signature of holder — Stamped signature of general managers of the French main line railways.

French lines over which it is available. It bears — for the last time, as all these railways have since been nationalised — the signatures of the General Managers of all the French main-line Railways.

(b) EDMONDSON SEASON TICKETS (figs. 315 to 318) are extensively used for short periods :

One day;
Five days, Monday to Friday (1);
Weekly, six or seven days;
Fortnightly;
Monthly (1).

They are issued but seldom for longer periods and differ from ordinary tickets by colour combinations or special markings.

Certain Railways have different tickets for each period (1) and also make a distinction when issuing them to gentlemen, ladies (or youths under 19, fig. 317) or again to children under 17 (Eire).

In addition to seasons for all passengers, special classes (categories) are sold at reduced rates :

Tourists (fig. 316) — 14 days (2);
Holiday contract tickets (1) — 7 days;
Workmen;
Children;
Juvenile workers.

Workmen's seasons bear no indication of the days of use (fig. 318) but are often only available before a certain time in the morning, while the return journey can either be undertaken at any time, or only after a given hour (3).

The service is simplified by omitting the number of journeys that may be made; abuse, if any, cannot amount to much. In Belgium, workmen's seasons are issued for :

One journey a week;
One week;
One week, Sunday excepted;
Two weeks;
One month.

In return for the reduced rates, most Companies refused to accept any liability for accidents (4). This is no longer so with the four British main-line Railway Companies.

Day tickets were introduced to increase tramways and bus traffic. Thus the *L. C. C. Tramways* sold (5).

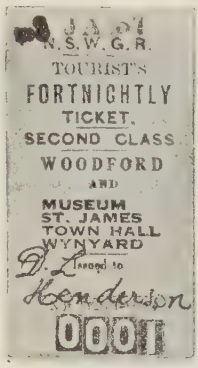
Saturday or Sunday tickets (fig. 323);
Similar tickets for children;
Evening tourist tickets costing 6 d. for the north or the south section.

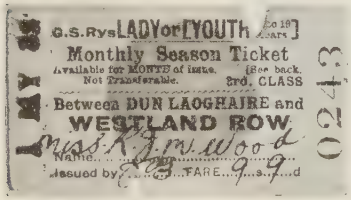
In Liverpool (fig. 324), different seasons valid for any one day of the week, which was shown by perforation (6), are issued to gentlemen or to ladies.

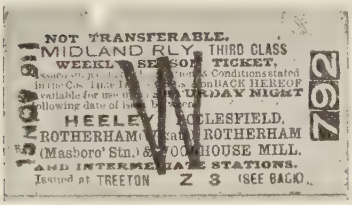
(c) SEASON TICKETS OR FREE PASS CARDS. — Some of the British cards are exceptionnally thick and even have gilt edges *(fig. 23)*.

Their size varies a good deal. In Belgium, they are 9 by 13 1/2 cm. (3 1/2" × 5 3/8"), roughly the same as postcards, which are 9 by 14 cm. (3 1/2" × 5 1/2"). The double cards are too big : 8 or 8 1/2 by 12 cm. (3 1/4" or 3 3/8" by 4 3/4").

(1) *Great Southern Rys.*, Eire.
(2) *New South Wales Government Rys.*
(3) *London, Tilbury and Southern Ry.*, after midday.
(4) The *Midland Ry.* limited the extent of its liability to £ 100.
(5) The date the ticket expires is shown by perforation; the ticket is clipped on each journey.
(6) From 10 a. m. to 11 p. m.







Edmondson seasons. (Red. 4/5).

Fig. 315. — Weekly season ticket between fixed places, *Belgian State Rys.*, about 1845 — Blanks for insertion by hand of name of holder, date and train numbers.

Fig. 316. — Tourist's fortnightly season ticket between fixed places — *New South Wales Govt. Rys.*

Fig. 317. — Lady's or youth's monthly season ticket — With circular coloured overprint — *Great Southern Rys.*, Ireland.

Fig. 318. — Weekly season ticket — *Midland Ry.* — Available at intermediate stations — Surcharged with a « W » (Woman).

The standard German cards are 45 × 70 mm. (1 3/4" × 2 3/4") and the Dutch, 6 1/2 × 9 cm. (2 1/2" × 3 1/2").

American road transport passes are generally 2 3/4" by 3 1/2". The size of certain classes has been altered a little to prevent confusion (figs. 309 and 310).

To distinguish them the more easily from other tickets, different shapes are sometimes used for seasons. In England, the *Great Western Ry.* has well engraved octagonal cards (fig. 326). The French *Nord* uses double octagonal cards for 1st-class seasons and oval ones for 2nd class (figs. 327-328).

In New South Wales, the shape of the cards varies according to the category; they are trapeziform for children, octogonal for ladies, rectangular for men, and oval for apprentices and workmen *(figs. 118 to 120)* (1).

Road Transport Companies use cards for season tickets (2).

Early FREE PASSES were often made of tougher material than ordinary paper or cardboard, such as parchment *(figs 24 and 25)*, linen paper (fig. 330), or linen cardboard in the States. The corners of some of the passes were rounded off; others were octagonal in shape (figs. *113* and *114*).

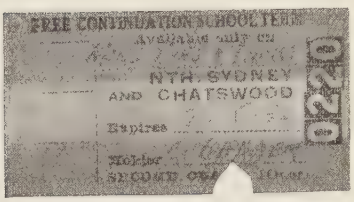
Several early European free passes were very carefully printed, but none of them were as beautifully engraved as the American ones produced by the *National Bank Note Co.*, of New York, and others (fig. 331).

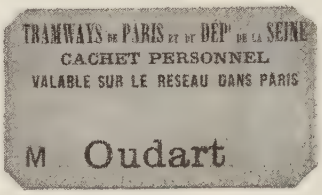
Nowadays, the size of American free passes has been standardized and they are all 4 3/4" by 2 1/2". They are ar-

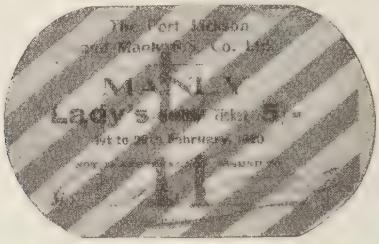
(1) The days of the week were printed all round the elliptical workmen's tickets issued by the *Tramways Mécaniques des Environs de Paris*, with a space for the outward and one for the return journey each day.

The *London General Omnibus Co.* also used multi-journey oval cards.

(2) « Anywhere ticket », *Western S. M. T. Co. Ltd;* « Day ticket », *Thames Valley Traction Company.*







Seasons and passes (Red. 4/5).

Fig. 319. — Free continuation school term — *New South Wales Government Rys.* — Three colours : white horizontal band between green and red ones.

Fig. 320. — Personal free pass, with holder's name, Paris, 1857.

Fig. 321. — Monthly lady's season ticket — *Port Jackson and Manly S. S. Co. Ltd.* — Coloured stripes on white background.

tistically produced in one or several colours, sometimes with a safety background (fig. 332); they always bear the signature of at least one of the Company's officers.

A map of the system over which they are available is frequently printed on the back of the European cards (fig. 333).

2. « **Multi-journey** » **tickets** (American so many ride passes).

These tickets encourage travel by the granting of reduced fares for a number of journeys. It is rather difficult to decide just how much such a reduction should amount to; if it is too small, the passenger won't risk buying the ticket in case he will not use it fully, but the company is assured that an excessive number of journeys will not be made by the same person.

These tickets are issued for :

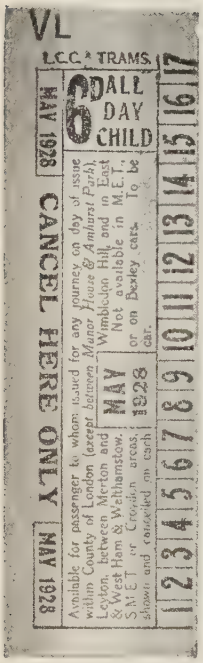
A number of trips made either way;

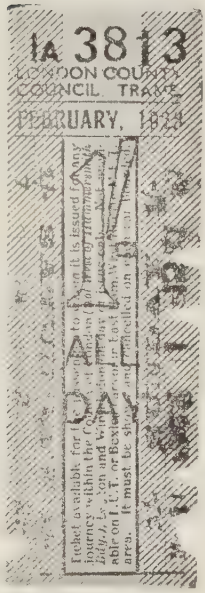
A number of outward and return journeys;

A number of journeys together with a right to reduced fares for extra trips as long as the ticket is valid.

We shall consider the latter when dealing with reduced rates in connection with legitimation cards.

Obviously, each journey made must be checked so as to see that the tickets are properly used, and to what extent : they must therefore be dated and have a space for each trip. The method used to accomplish this will determine which kind of ticket should be provided. We shall take them in the following order :





London County Council Tramways day season tickets. (Red. 4/5).

Fig. 322. — Soft card all-day child's ticket — Printed with year, month and fortnightly list of dates for clipping — Conductor's cancellation on opposite edge — Colour : white band between coloured ones.

Fig. 323. — Saturday or Sunday all-day ticket — Close ruled diagonal black lines as additional clipping safety background.

Checking by perforation and clipping :

(a) and *(b)* Edmondson and various size cards;

Collecting a coupon for each trip :

(c) Cards with coupons;

(d) Booklets of sheets of coupons;

(e) Booklets of paper tickets.

Collecting an Edmondson ticket for each journey :

(f) Packets of tickets.

In *c* to *f*, countermarks are given in exchange for the check coupons collected, according to their class [1]. The ticket itself is sometimes divided into two portions, one of which is collected by the conductor.

(a) **Edmondson multi-journey tickets** are issued, when required, for short periods, mainly to workmen [2] who cannot afford to pay large sums at a time and whose employment is too unstable for them to buy multi-journey tickets for longer periods. We deal later with workmen's cards and booklets of paper tickets.

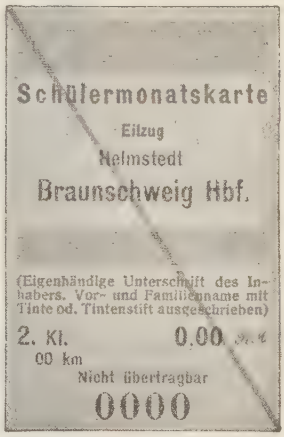


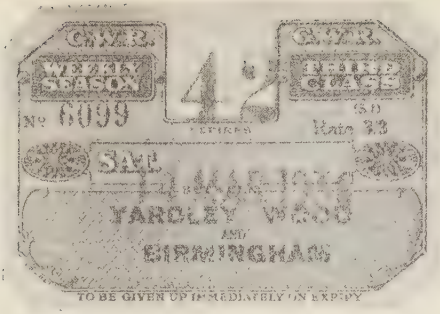
Fig. 324. — Lady's day ticket. (Red. 4/5) — *Liverpool Corporation Tramways* — Clipping in list of days of the week.

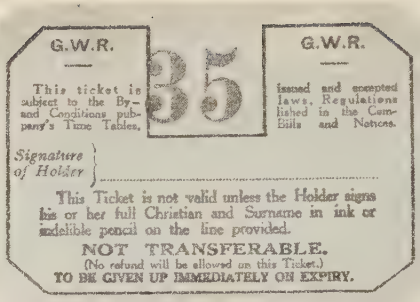
Fig. 325. — Standard blank scholar's monthly card ticket. (Red. 4/5) — German *Reichsbahn* — Two safety grids for writing on.

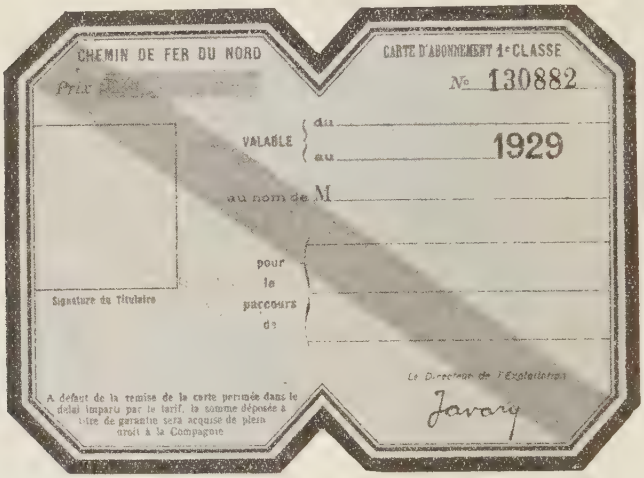
---

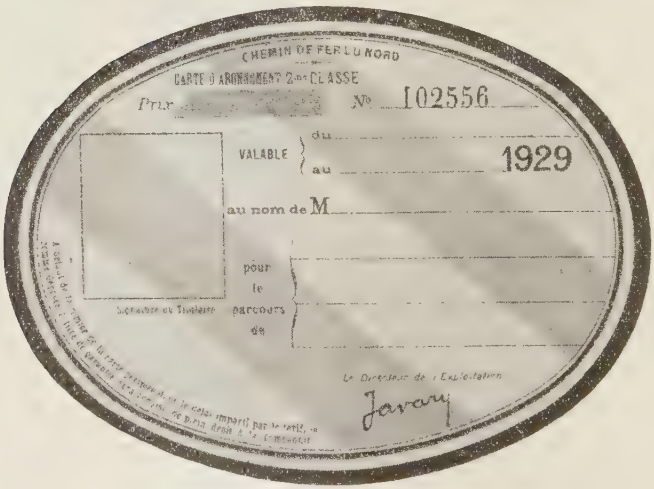
(1) *Territet-Glion Cable Ry. (fig. 296).*

(2) Whereas in England and in Belgium, the Railways use the term « workmen » and the buses sometimes « workpeople », in America the terms « working man » and « working woman » appear frequently.




G.W.R.
This ticket is subject to the By- and Conditions pub- pany's Time Tables,
35
G.W.R.
issued and accepted laws, Regulations lished in the Com- Bills and Notices.
Signature of Holder
This Ticket is not valid unless the Holder signs his or her full Christian and Surname in ink or indelible pencil on the line provided.
NOT TRANSFERABLE.
(No refund will be allowed on this Ticket.)
TO BE GIVEN UP IMMEDIATELY ON EXPIRY.





Season ticket cards (Red. 3/4).

Fig. 326. — Front and back of weekly season ticket — *Great Western Ry.* — Well engraved with safety background.

Figs. 327 and 328. — Octogonal 1st and oval 2nd-class monthly season tickets, French *Nord Ry.* — The number of broad diagonal bands shows the class.

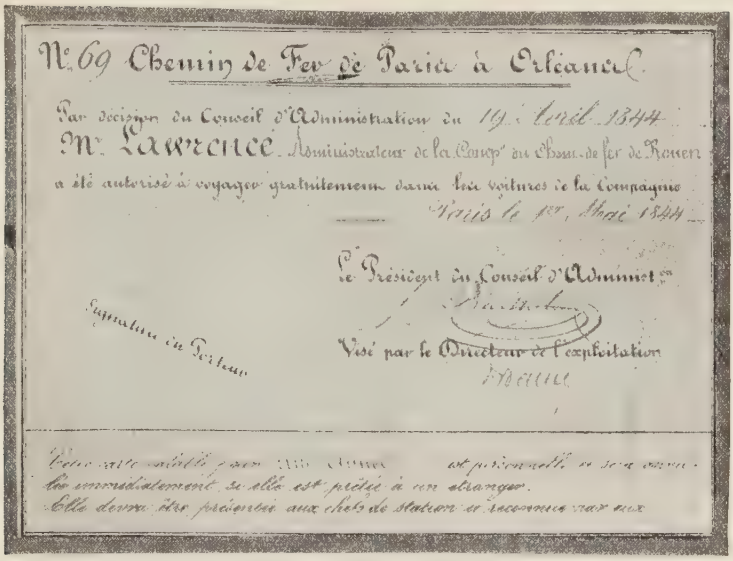

N° 69 Chemin de Fer de Paris à Orléans
Par décision du Conseil d'Administration du 19 Avril 1844
M. Lawrence Administrateur de la Comp.ie du Chem.in de fer de Rouen
a été autorisé à voyager gratuitement dans les voitures de la Compagnie
Paris le 1er Mai 1844
Le Président du Conseil d'Administration
Signature du Titulaire
Visé par le Directeur de l'exploitation

Fig. 329. — Free pass, 1844 (Red. 3/4) — *Paris-Orléans Ry.*

Special weekly tickets are also issued to some classes of workers such as

Colliers — *Neath and Brecon Ry.;*
Quarrymen — *Corris Ry.;*
Miners — Wales.

As it is essential to issue these tickets quickly, the distinction between workmen and the few other passengers travelling as early as they do in the morning has sometimes been abolished, but the tickets are valid only on workmen's trains (1). Elsewhere, workmen must travel at the same time every day, which would appear to be a source of worry both to the Railways and the employers (2).

Through workmen's tickets may be available in different classes on the several railways (3).

All these tickets cover several journeys accomplished in a period of :

A week of 7 days;
A week of 6 working days;
Five, four, or even three days a week;
One or two outward and return journeys a day;
A single journey one way each day (4).

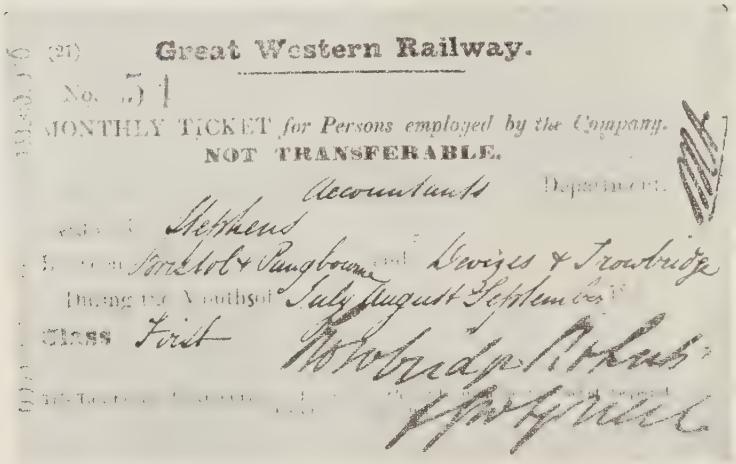
Packets of Edmondson tickets are also issued, one of the tickets being available

(1) *Taff Vale Ry.*

(2) *New South Wales Government Rys.*

(3) *Belgian National Rys. Co.* and *Belgian National Light Rys. Co.*, 3rd and 2nd class respectively.

(4) « Late Workmen's » tickets.
Workmen's holidays *(Netherlands Rys.)*.
Holidays with pay (France).
8-day or 15-day excursions *(Taff Vale Ry.)*, etc.



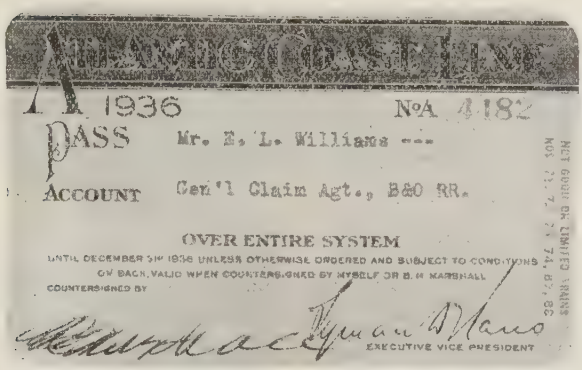
Free passes.

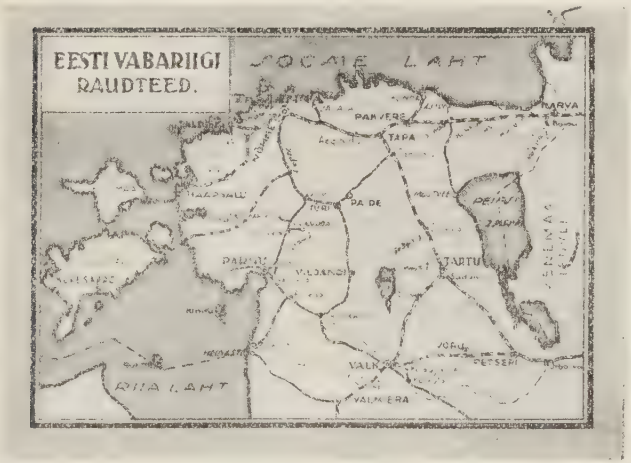
Fig. 330. — Monthly staff ticket or pass, 1852 (Red. 3/4) — *Great Western Ry.* — Linen paper.

Fig. 331. — Annual pass, 1870 (Actual size) — *Erie Ry.* — Beautifully engraved by the *National Bank Note Co.*, of New York — Safety background : engraved design covering the whole of the card.

each day of the week (fig. 339). But it is more usual to issue Edmondson tickets each of which is valid an entire week (figs. 334 to 336). They have a number of spaces one of which must be perforated each day; most of them even have separate spaces for the outward and the return journeys (1). The number of

(1) *Great Western Ry.* — The outward journeys are numbered 1, 2, 3 and so on along the top edge; the return journeys are shown by the initial letters of the days of the week, W, Th, F, Sat., etc. along the lower edge.


1936
No A 4182
PASS
Mr. E. L. Williams
ACCOUNT
Gen'l Claim Agt., B&O RR.
OVER ENTIRE SYSTEM
UNTIL DECEMBER 31st 1936 UNLESS OTHERWISE ORDERED AND SUBJECT TO CONDITIONS
ON BACK, VALID WHEN COUNTERSIGNED BY MYSELF OR B. H. MARSHALL
COUNTERSIGNED BY
EXECUTIVE VICE PRESIDENT



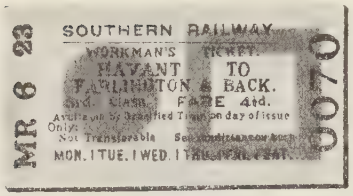
Free passes (Red. 3/4).

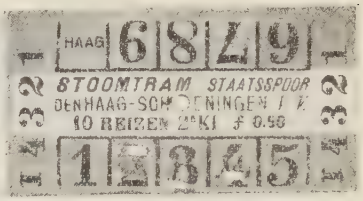
Fig. 332. — Standard American pass — *Atlantic Coast Line* — Signature of principal passenger department officers — Stamped title of Company.

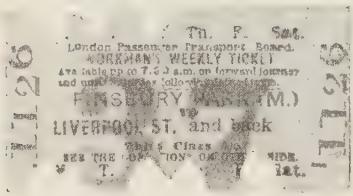
Fig. 333. — Back of an *Estonian State Rys.* free pass — Two-colour map of the system.

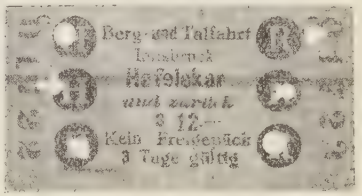
the week is clearly shown, frequently by means of a large overprinted numeral. Occasionally, double Edmondson tickets are used, the second portion serving for perforation purposes only (fig. 338).

Another problem immediately arises : that of the weekly renewal of the tickets which takes place at the same time for most of them, and is further complicated by the fact that the workmen must prove their status before being allowed to purchase them. Certain Railways have solved this very ingeniously by dissociating the ticket from such proof. The identity









Edmondson multi-journey tickets (Red. 4/5).

Fig. 334. — Weekly workman's season for travelling to a non-staffed halt — *Southern Ry.* List of days of the week for snipping — Date stamped in ink — Circle and rectangle overprint in second colour, showing availability as a return ticket.

Fig. 335. — Weekly multi-journey ticket for one daily return journey — *London Passenger Transport Board* — Notched by conductor — Number of the week surcharged.

Fig. 336. — Multi-journey ticket available for 10 single journeys — *Hague-Scheveningen Steam Tramway — Netherlands State Rys.*

Fig. 337. — Ticket for three return journeys — *Innsbruck Hafelekar Mountain Ry.* — One space punched on each of the six trips with nippers perforating differently designed holes — Available for 3 days.

ticket or card is acquired once for all, so that it is only necessary to exchange the old trip-ticket for a new one available for the following week; this can be done very quickly as the new ticket can be prepared beforehand. The identity ticket or card gives the name of the holder and bears his signature; it states the journey and the price per week. It is really an identification card, while the ticket with the number of the week is a mere receipt. In Belgium both are Edmondsons carried together in a special ticket holder (fig. 469).

Edmondson multi-journey tickets are occasionally issued to other classes of passengers as well (fig. 337) (1).

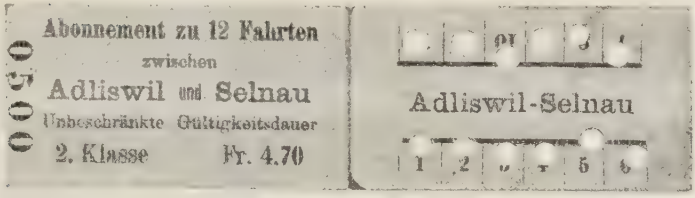
British road transport Companies, and sometimes French ones, also issue them to workmen, but seldom to others, as cards or booklets are more handy.

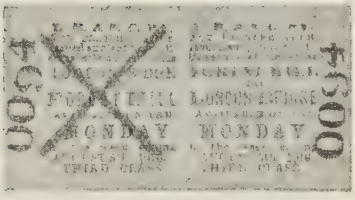
(b) **Multi-journey cards** are widely used on the American railways where they are known as commutation tickets (2), but rarely in Europe. These American tickets are issued for 10, 25 (3), 27, 30, 46, 54, 55, 56, 60, 62, 100 or 180 trips,

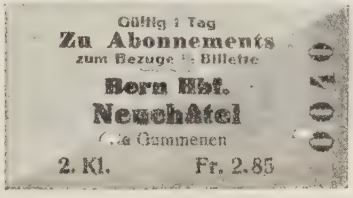
(1) Edmondson tickets are good for three double-journeys between Innsbruck and Hafelekar. Each of the 6 trips is perforated in turn.

(2) *The Grand Trunk Ry. System*'s bilingual tickets are entitled « billets commutatifs ». a literal translation.

(3) 25 trips on the *Grand Trunk*. 27 on the *Chicago, Indianapolis and Louisville Ry.*







Edmondson tickets (Red. 4/5).

Fig. 338. — 12 multi-trip fixed journey ticket — *Swiss Federal Rys.* — Detachable portion with punching spaces.

Fig. 339. — Packet monday ticket — *London, Brighton and South Coast Ry.* — Final date of availability of the last ticket in the series is marked — Return coupon with a St. Andrew's cross.

Fig. 340. — Ticket issued to holder of a half-rate card — *Berne-Neuchâtel Direct Ry. Co.* — Divided diagonally in two colours.

there being, for each, a numbered space which has to be perforated (fig. 343). The peculiar number of some of the trips is due to the tickets being available on Sundays or not and to the different number of days of the months.

Every trip is numbered consecutively on the cards, more rarely separately for the outward and return journeys. Even in this case, all numbers are on the same face of the card, the outward above, the return beneath (1).

Most tickets are provided with a stub which is retained by the booking clerk. Some have a second stub which is valid for the first journey and is collected by the first conductor. The numbers of the trips then begin with Number 2. This additional coupon does not exist on tickets beginning with Number 1.

The number of the last trip is also omitted as the card itself, which the last conductor collects, covers this. The series of numbers are thus minus the first and last numbers.

Special classes (categories) exist :

Suburban tickets for the same numbers of journeys as the others;

Employees' tickets for 10 to 54 journeys;

Scholars' tickets for 46 and also for 31 journeys.

All these are valid for one month; there are, in addition :

12-ride weekly tickets;

52-ride semi-weekly family tickets (2);

(1) *Illinois Central R. R.*, 54 return journeys.

(2) *Chicago, Burlington and Quincy R. R.*

American 25-ride card tickets (Actual size).

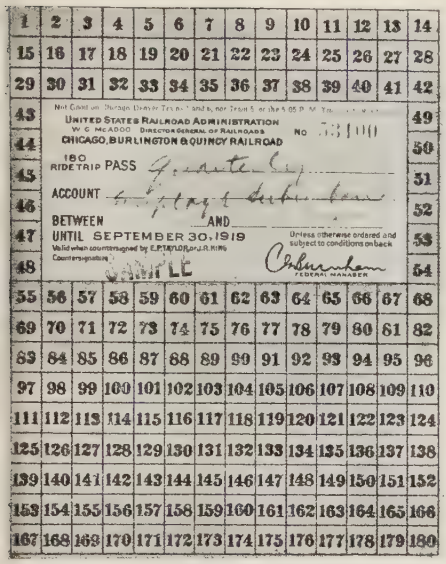
Fig. 341. — Beautifully lithographed *Chicago, Burlington and Quincy R. R.* semi-blank commutation ticket — Valid for 25 rides — Punching spaces for 2nd to 25th ride — Agent's stub and auditor's check valid for 1st ride.

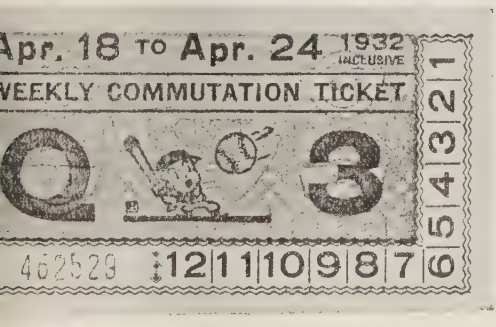
Fig. 342. — *Illinois Central* blank engraved ticket — Available for one year, in suburban trains only — Spaces for 24 ride numbers and auditor's detachable coupon for the 1st ride.

180-ride employees' quarterly tickets (1);
156-trip business quarterly tickets (2);
Half-yearly 26-ride family tickets (3);
Annual tickets (1).

Some of these tickets, such as the *Chicago and North Western Ry.*'s, are finely engraved, and notable examples of the American graphic art. Others, like those of the *Chicago, Burlington and Quincy R. R.*, are beautifully lithographed in

(1) *Chicago, Burlington and Quincy R. R.*
(2) *Central of Georgia.*
(3) *Wabash Ry.*


UNITED STATES RAILROAD ADMINISTRATION
W. G. McADOO DIRECTOR GENERAL OF RAILROADS
CHICAGO, BURLINGTON & QUINCY RAILROAD
180 RIDE TRIP PASS
ACCOUNT
BETWEEN AND
UNTIL SEPTEMBER 30, 1919
Unless otherwise ordered and subject to conditions on back
FEDERAL MANAGER



Multi-journey (commutation) tickets. (Red. 3/4).

Fig. 343. — Three-monthly ticket available for 180 rides, United States Railroad Administration (1914-1918) of *Chicago-Burlington and Quincy R. R.* — Not available on certain crack express trains — Continuous safety background.

Fig. 344. — Weekly 12-trip ticket — Printed extreme dates of availability — Surcharged with distinguishing symbol and design relating to the week — Safety background.

green on a yellow background (figs. 341 and 342).

Similar cards are used in Europe, where tickets for 6 journeys (1), 10 return journeys (2), or, as in Switzerland, for 12, 25, 50 or 100 journeys, are to be found.

In Germany, tickets of standardized dimensions are issued to scholars for a daily single or return journey, Sundays excepted (fig. 325). Formerly, fourth-class tickets with a small reduction were also issued mostly to groups of agricultural labourers.

Though tickets for repeated journeys are not very widely used on the European Railways, they are extensively used by Road Transport; the number of journeys generally varies from 5 to 7 (3). Since the introduction of a special totalizer punch, 20-trip cards are used in Brussels and other Belgian cities (see Part G, checking, and *figs. 530, 531).*

Identification of a journey differs according to whether the tickets have preprinted lists or not.

The former list a series of factors such as the date, hour, day of the week, which determine each journey; where rates are not uniform, a printed list or graphical representation of the stages appears. These tickets are often very big (fig. 351). Each trip is shown in turn by perforation (fig. 348), by clipping (fig. 346), or by tearing off a corner (fig. 349).

---

(1) *Mersey Railway*, England.

(2) *Belgian National Rys. Co.* — This ticket is a double strong paper card.

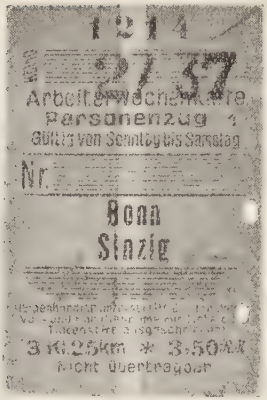
(3) At Hagen three return journeys. The outward journeys are punched in one column, and the return ones in an adjoining column.

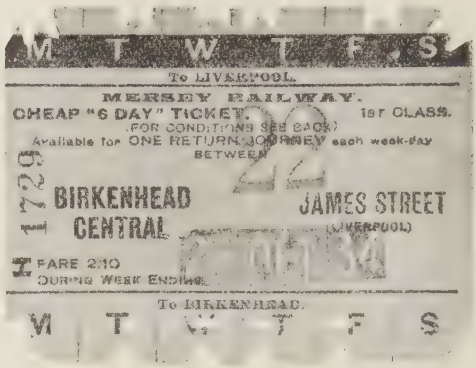
At Stolp, five journeys.

In Berlin, a corner was torn off on each of the four first trips, and the rest of the card served for the fifth.

Six journeys in Dortmund, Leipzig and Bonn.

Seven journeys in Rostock and on the *Mons Light Railways.*





Season ticket cards (Red. 3/4).

Fig. 345. — Weekly workman's season ticket — German *Reichsbahn* — Safety grids for hand-written data — Fixed journey — Printed class, distance and fare.

Fig. 346. — Cheap 6-day multi-journey ticket between fixed places — *Mersey Ry.*, England — Overprinted with final date of availability and number of the week — Outward journey spaces printed in ordinary type, inward in negative type — Cancelled by perforation and nipping.

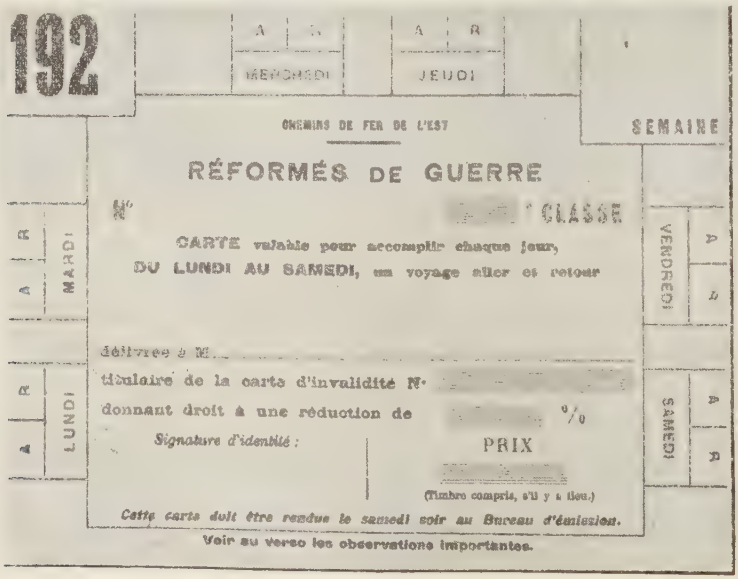
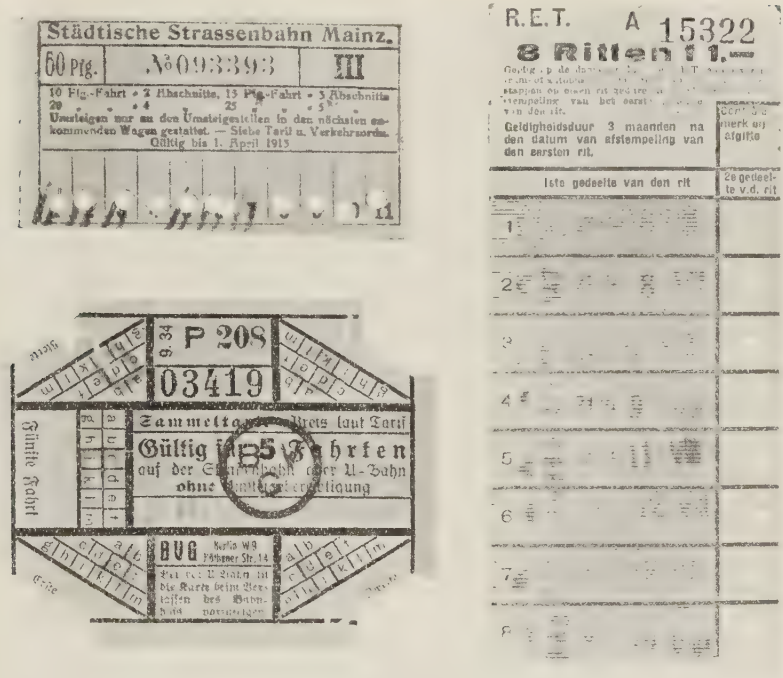


Fig. 347. — Semi-blank ticket for 7 return journeys for war disabled (Red. 3/4) — French *Est Rys.* — Space for each trip.



Multi-trip cards (Red. 3/4).

Fig. 348. — Ticket with 12 fare spaces — *Mainz Municipal Tramways* — Table of fares — Six-figure serial numbering.

Fig. 349. — Obsolete Berlin 5-trip ticket — Corner torn off for cancelling ride — Punched control letter — Printed in two colours with partial safety background. .

Fig. 350. — Ticket for 8 through journeys — *Rotterdam Electric Tramways* — Two spaces per journey, one to be date-stamped by conductor of first tram boarded, the other to be punched by the conductor of the second — Available for 3 months — Safety grids for ink-stamping dates and times.

The second sort of ticket is much less complicated; it has a number of empty spaces, one of which is stamped for each journey made, and clipped by special cutters (fig. 350).

Scholars' cards. — Although seasons are generally used, often with restrictions as to hours during which they are valid, other cards are available for a number of journeys only, ten usually on American road transport lines. The determination of the fare takes into account the fact that the scholar travels one way during the morning rush hours and returns home during the afternoon slack period. The fare has therefore been established between that of a multi-journey ticket available at any time and that of a Shopper's ticket which is only valid during the slack hours (1).

(1) In St. Louis, these extreme fares are 9 cents for the former, 5, for the latter; the scholar's has been fixed at 7 cents per trip, making 70 cents for the ticket.

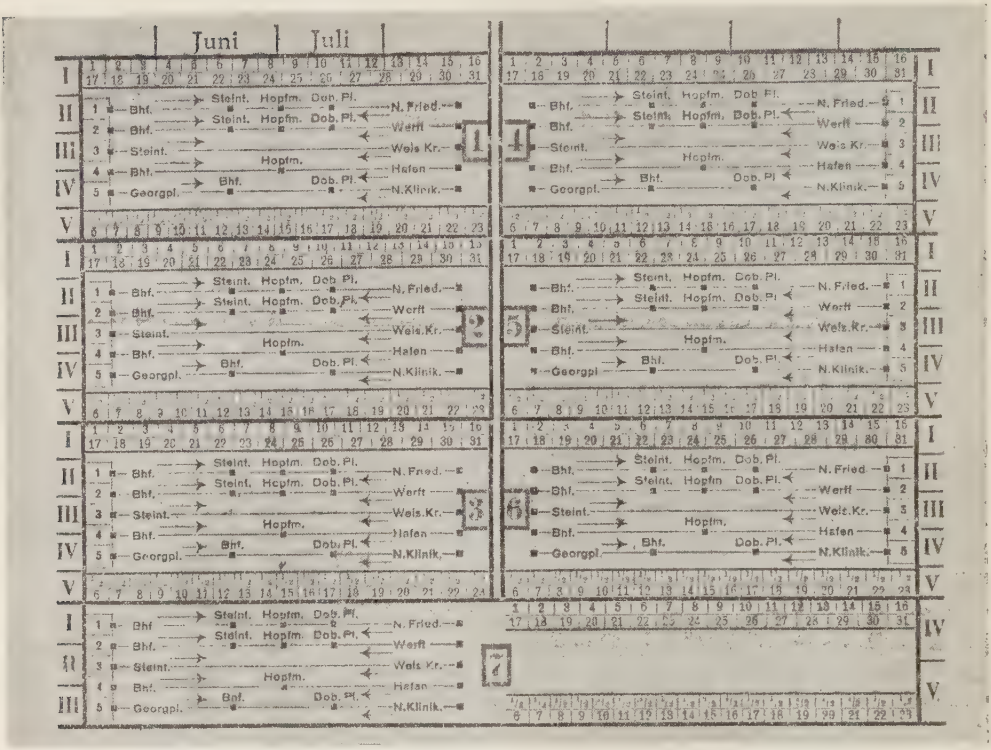


Fig. 351. — Ticket for 7 return journeys — *Rostock Tramways Co.* (Red. 3/4) — Lists of routes, date and stage points for each journey — Arrows indicate direction of travel — Journey numbers printed in red.

The tickets also differ according to whether they are issued to males or females.

They are valid for one week, one month, or longer. On certain lines (1) the quarterly tickets for daily return journeys are printed with a list of the days of four months twice over, so that it is possible to begin using them on any day of the month. Each space is perforated through the date on which the journey is made.

There are scholars' tickets of all kinds, others for University students and for different special schools. Thus the *New South Wales Government Rys.* issue tickets for :

Free continuation school term;
Free week-end school term;
Free school term;
Free manual school term.

FREE (CARD) MULTI-TRIP PASSES. — Besides free passes granted for short periods,

(1) The *Intercolonial Ry.*, Canada, has tickets for two daily return journeys, numbered from 1 to 31 four times over.

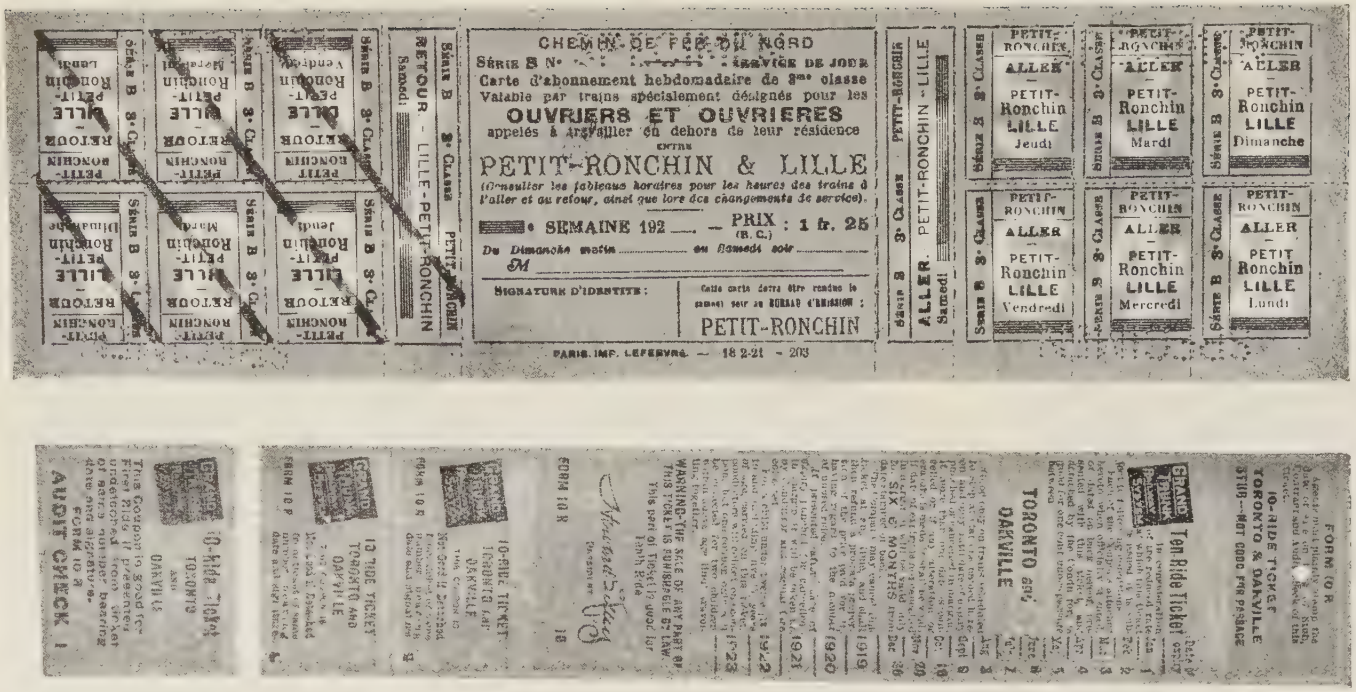


Fig. 352. — Multi-journey card with detachable coupons, 1921. (Red. 3/4) — French *Nord Ry.* — For workmen and workwomen — Trip number or day of the week in white — Number of the week inserted in writing — Millesim (date) of printing — Each of the 14 coupons has a grid for the date when the ticket is used.

Fig. 353. — Ten-ride card ticket with detachable coupons (Red. 3/4) — *Grand Trunk Ry. System*, Canada — Available for 6 months — Final date of availability shown by punching the year, month and day.

others are issued for one, or occasionally, for several return journeys.

In Belgium, the successive journeys are written on the back of the card, whether personal or otherwise.

Fig. 354. — Detachable-coupons for the new system of workmen's multi-journey tickets. French *Nord Ry.* — Outward and return journeys alternate — The ticket number is repeated on each coupon.

(c) **Card-tickets with a detachable coupon for each journey** are not much used on European railways, where other methods have been preferred. The *Nord* formerly issued workmen's weekly cards of the sort with the coupons either outward on one side and inwards on the other (fig. 354) (1) or all on the same side. This method was abandoned when it was decided to separate the identification of the passenger from the ticket proper.

The new paper tickets (fig. 352) consist of sheets of 14 coupons for the week, with a stub which enables the holder of the identification card to buy, when he hands it in, another sheet of coupons for use during the ensuing week. Did he retain the stub, it would be possible for him to purchase several reduced-fare weekly tickets and to retail them to others who have no right to them (2).

Both in England and on the Continent, Road Transport also uses cards with coupons available for from 4 to 8 days (3).

Long narrow coupon strip-cards whose coupons stretch right across are used for short trips in America (fig. 353). They usually comprise 10 coupons, occasionally as many as 50 (4) or as few as 5. Party strip-cards are available separately for any member of the group.

Certain Continental road transport Companies use cards having vertical and horizontal cross perforations (Carlsbad, fig. 355), each perforated rectangle being valid for one trip.

(d) **Booklets of sheets of coupons** are also widely used for short journeys in America *(fig. 85*, fig. 360). The sheets are usually made of stout paper or thin

(1) The numbers are very clearly shown in white on the coloured background proper to the class. The return coupons are overprinted with red diagonal lines.

(2) See Messrs. CHAPERON and RICHARD's interesting article in the *Revue générale des Chemins de fer*, December 1930.

(3) On the *Wn. S. M. T. Co. Ltd.* all the coupons are in two columns at the bottom of the cards, those in the left-hand column being detached first.
The *Campion Bus Service* uses cards with two rows of coupons, one above the other.
The cards of the *Pompey Autobus Co.*, of Nancy, are good for two daily return journeys. On the right-hand side are three columns of four coupons, those at the top of the right-hand column being detached first.

(4) On the *Grand Trunk Ry. System*, the *Intercolonial Ry.*, Canada, the *St. Louis and San Francisco*, the *Canadian National* which also issues strips of 50 coupons.

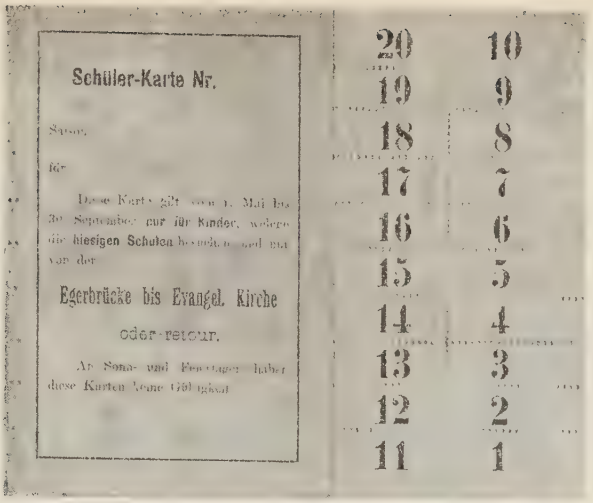


Fig. 355. — Scholar's multi-journey detachable-coupon ticket (Red. 3/4) — *Carlsbad* (Karlovy Vary) *Motorbuses.*

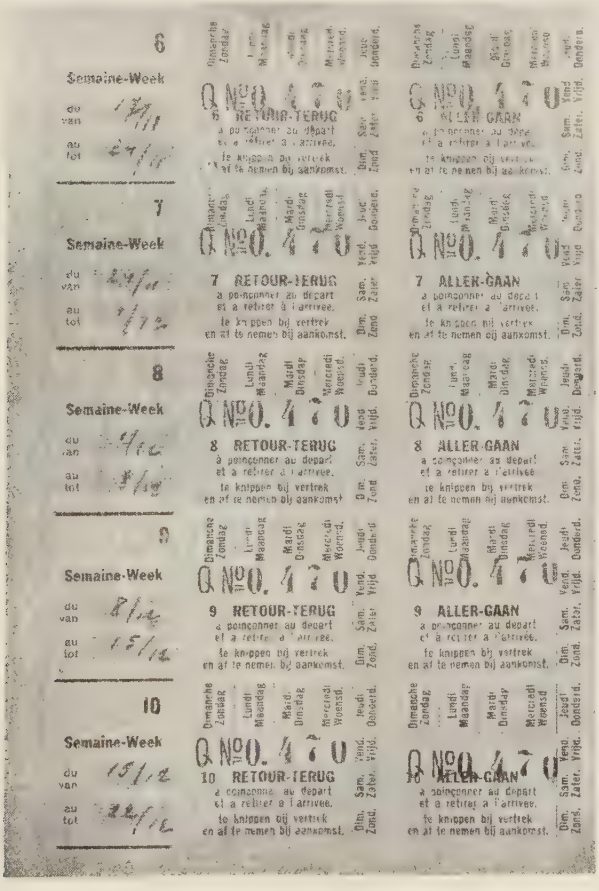


Fig. 356. — Sheet of scholars' multi-journey detachable coupons (Red. 3/4) — *Belgian National Rys. Co.* — Two coupons to be punched daily, one on the outward, one on the return journey.

card. The coupons, four or five to the sheet, are small, 7/8" to 1" by 2" to 3". Each coupon is printed with the number of the book, together with its own serial number. The day of the month is sometimes overprinted in large coloured numerals (1).

American card fare coupons (Red. 4/5).

Fig. 357. — *Metropolitan R. R.*, 1886.

Fig. 358. — *Water Works Ry.*, City of St. Louis.

Fig. 359. — Ticket sold at a reduced rate of 3 for 25 cents — *Chicago Rapid Transit Co.* — Partial safety background, consisting of a view printed in red.

Books printed on safety paper, with 2 or 3 coupons per sheet, are usually bound on the left side instead of the top as are the others. Should the number of coupons not tally with the number of sheets, the remaining portion of the last sheet remains blank *(fig. 30)*. The paper is often watermarked.

In the larger Canadian towns, the coupons are printed in sheets like postage stamps (fig. 362). Scholars (under 16) and students (over 16) have books of special coupons (fig. 360).

There are 10 to 60 coupons in such books, for various classes of passengers :

Ordinary passengers, bearer books;
Ordinary passengers, personal books for 10, 25, 40, 50, 54 or 56 rides;
Children;
Scholars — 46 rides in one month (2);
Family — 30 rides (3);
Employee's commutation ticket — 30 rides;
Family summer resort and sea bathing — 5 rides (4).

Urban and Suburban systems encourage traffic for educational purposes :

Day school ticket;
Student's ticket;
Scholar's ticket;
Local school ticket (5);
Child's educational group ticket (5);
Collector's child ticket (5), etc...

In all cases precautions are taken to prevent fraud. The penalties include fines up to $ 100, imprisonment for one year, or both (6).

(1) *Southern Pacific.*

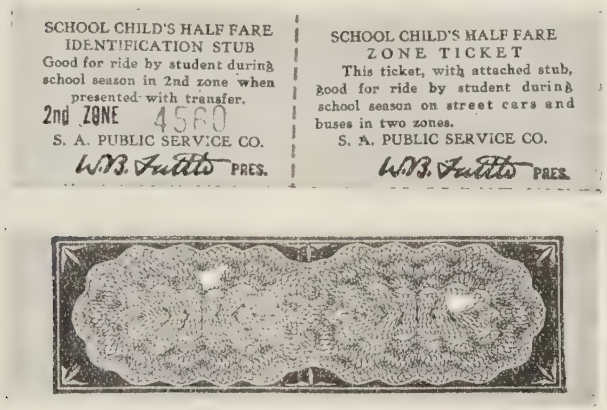
(2) *Dayton, Covington and Piqua Traction Co.*

(3) *Central of Georgia; Illinois Central R. R.*

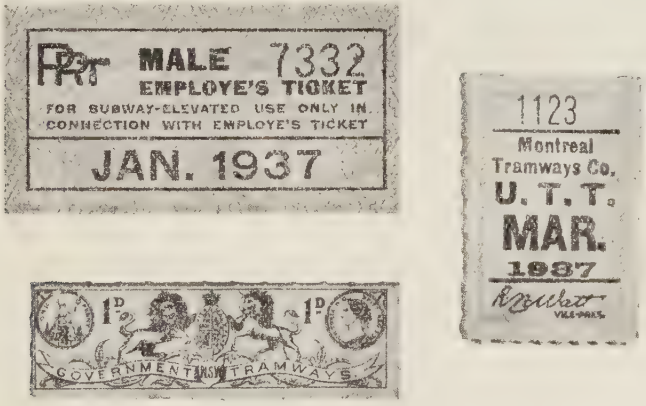
(4) *Intercolonial Ry.*

(5) *Chicago Rapid Transit.* — On the *Baltimore Rapid Transit*, there are never more than 26.

(6) On the *United R. R. or San Francisco* : « Misuse or misrepresentation of age (Ordinance No. 279 approved April 22nd, 1901) punishable by a fine of $ 100 or 50 days in the county jail, or both such fine and imprisonment. »


SCHOOL CHILD'S HALF FARE
IDENTIFICATION STUB
Good for ride by student during school season in 2nd zone when presented with transfer.
2nd ZONE 4560
S. A. PUBLIC SERVICE CO.
W.B. Futtis PRES.
SCHOOL CHILD'S HALF FARE
ZONE TICKET
This ticket, with attached stub, good for ride by student during school season on street cars and buses in two zones.
S. A. PUBLIC SERVICE CO.
W.B. Futtis PRES.

Figs. 360 and 361. — Front and back of a scholar's half-fare zone ticket coupon (Red. 4/5) — *S. A. Public Service Co.* — Available for a transfer journey in two zones if accompanied by a corresponding ticket — Intaglio machine interwoven safety background on back.



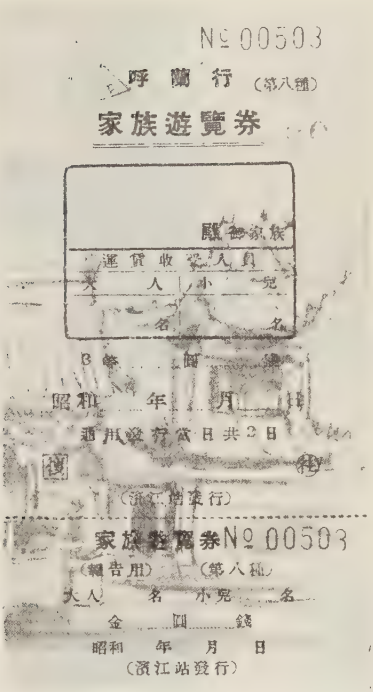
Various coupons (Actual size).

Fig. 362. — Booklet sheet of coupons — *P. R. T.* — Continuous safety background — Pre-printed date — Category : male employee.

Fig. 363. — Penny-fare coupon, *New South Wales Govt. Tramways*, Sydney — Beautifully engraved.

Fig. 364. — One-fare coupon, *Montreal Tramways Co.* — Line perforated all round — Pre-printed date — Officer's signature.

Some of the Continental booklets have sheets of coupons perforated like postage stamps. The *Belgian National Rys. Co.* scholars' sheets consist of a series of rows of two coupons printed with the days of the week (fig. 356). Each cou-



Figs. 365 and 366. — Booklet paper tickets (Red. 3/4) — *Japanese Rys.* — Safety background consisting of a view printed in a second colour.

pon is punched on the outward, then on the return journey, and detached at the end of the week.

(e) **Booklets of paper or cardboard tickets** are widely used in Europe. Urban railways issue booklets in advance (1) *(figs. 87 and 88)*, and main-line Companies, books of paper tickets for their suburban lines (2). Central European road transport Companies in Switzerland, Holland and elsewhere use them extensively (figs. *103 b*, 365 to 370). They generally hold a round number of tickets : 5, 10, 20, or else 12, which are often exchanged for countermarks (3) (fig. 370). In England, booklets of soft card tickets are supplied in the same way (figs. 373, 374).

There are special classes (categories) for :

Children;
Military;
Commercial travellers;
Employees' families (4);

(1) Paris *Metropolitain (fig. 87)*; London *Underground (fig. 88)*.
(2) Suburbs of Paris and the more important Dutch towns.
(3) In England and Germany. In Norway, 12 for one week, 50 for one month.
(4) *Tramways de Paris et du Département de la Seine.*

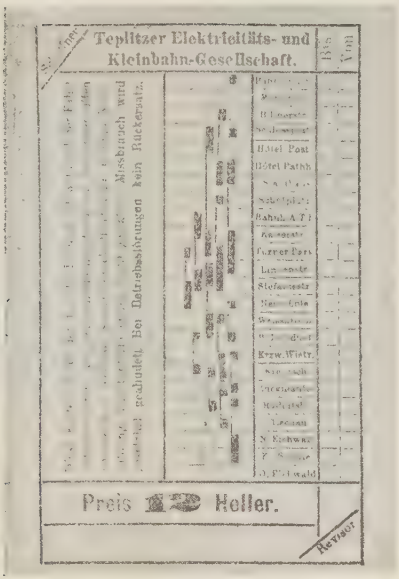


Fig. 367. — Paper coupon from a block sold at a reduced rate (Red. 3/4) — *Teplitz Electricity and Light Ry. Co.* — Available for journeys shown graphically — Spaces for punching opposite fare stage points on outward and return journeys.

Gemeentetram - Amsterdam.
CONTRAMERK
afgegeven tegen betaling met een kaartje, geldig voor hoogstens 3 Secties.
Dit biljet op verlangen te overhandigen
A 07428

Fig. 368. — Countermark for reduced fare ticket, available for 3 sections (Red. 3/4) — *Amsterdam Municipal Tramways* — List of sections — City's coat of arms — Surcharged with distinctive colour band including white reserves.

Reichenberger Strassenbahn.
Früh Uhr 1 2 3 4 5 6 7 8 9 10 11 12
Diese Anweisungen berechtigen nicht zur Durcharbeitung der Mittagspause, da hiefür keine Entschädigung erfolgt.
Arbeits-Anweisung
ani ..... 191.....
Auszahlung nur gegen Abgabe dieses Scheines.
Aufnahme ohne Kündigung.
..... Stunden .....
Die Betriebsleitung.
Nachmittag Uhr 1 2 3 4 5 6 7 8 9 10 11 12

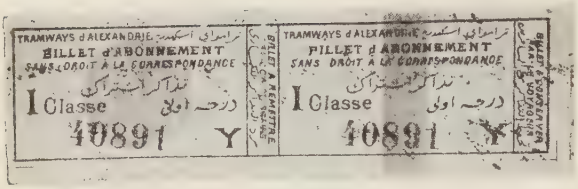
Fig. 369. — Workman's check (Red. 3/4) — *Reichenberg Tramways.*

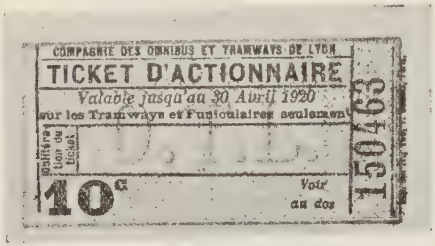
Workmen (1) (fig. 374);
Sometimes for males and females (2);
And even for the Company's shareholders (Lyons, fig. 371).

Various sorts of excursion booklets of tickets are also sold, as in Frankfort where family booklets for 5 return journeys are available during the July and August summer holidays. They are sold with a 20 per cent reduction and cost 2 Rm. instead of 2.50. The only restriction that applies to them is that the user must return on the same day from the periphery point which the outer journey brought him to (3).

Booklets of the kind also exist in America (4) occasionally on railway lines (5)

(1) In *Newcastle*, besides books of 1/2 d. coupons, there are others « for a distance of 1 1/2 d. ».
(2) In Germany.
(3) The day is shown in green on tickets, the right side relating to the outward journey (« H », hin), the back to the return journey (« R », Rückfahrt).
(4) *Texas Electric Ry., Denver Try. Co.*, where they are known as commuter monthly coupons or tickets.
(5) *Intercolonial Ry.*, « local book ticket ».





COMPANHIA DE S. CHRISTOVÃO
E. DE F. DA TIJUCA
COUPON DE ASSIGNATURA
No 1,547
O SNR ASSIGNANTE TEM DIREITO A UMA PASSAGEM DA RUA CONDE DE BOMFIM AO ALTO DA BOA VISTA DU VICE VERSA
ESTE COUPON E INTRANSFERIVEL

Tickets from booklets of tickets (Red. 3/4).

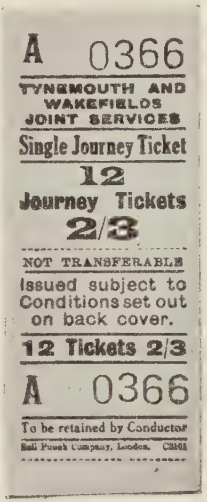
Fig. 370. — Ticket with check stub — *Alexandria Tramways*, Egypt, 1910 — Red overprinted distinguishing marks · Bilingual text in French and Arabic.

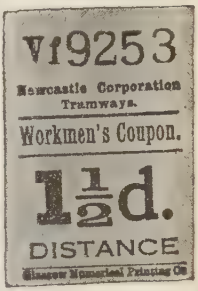
Fig. 371. — Shareholder's ticket — *Lyons Omnibuses and Tramways* — Cancelled by date-stamping — Safety background including Co.'s initials.

Fig. 372. — Paper ticket — *Tijuca Ry.*, Brazil.

more frequently in large cities (1) where they comprise :

10 to 50 or 60 coupons;
46 coupons for scholars;
18 to 50 coupons for settlers (2);





Blocks of soft card tickets sold at reduced rates (Red. 4/5).

Fig. 373. — Blocks of 12 single-journey tickets — *Tynemouth* and *Wakefield* joint services.

Fig. 374. — Workmen's coupons available for a distance covered by 1 1/2-d. fare — *Newcastle Corporation Tramways.*

And coupons for special categories of passengers, such as banana conveyors.

The usual precautions to prevent their being misused are taken (3).

The same idea is applied by tramway or bus Companies who sell special identity cards entitling the holder to purchase tickets at reduced rates. The Berlin « Monats-Grundkarten » (monthly identity cards) cost 4 Rm. for tramways, 5 Rm. for the U-Bahn, 8 Rm. for both, and 10 Rm. for all lines. Monthly identity cards for unemployed cost 25 Rpf. and enable the bearer to travel at 10 Rpf. per trip.

(1) On the *Baltimore Rapid Transit Co.*, « commuter's city fare ticket ».

(2) *British Columbia Electric Ry. Co.*, Vancouver.

(3) The *St. Louis and San Francisco Ry. Co.* prints the coupons on watermarked paper. The cover bears a description of the holder who, moreover, has to sign it before witnesses.

Similar weekly 50-Rpf. cards were introduced in Frankfort in 1933 and entitle the holder to travel at 10 or 20 Rpf., for short or long journeys (1).

C. MIXED PAYMENT, PARTLY IN ADVANCE AND PARTLY WHEN STARTING.

Season ticket holders may make an unlimited number of journeys which cost them less the more they travel. If the holder is not sure of using his ticket often enough to secure an advantage from having purchased it, he may find it better to buy, for a smaller sum, a card entitling him to obtain any number of tickets at a reduced rate. The actual cost of each journey must take a fractional payment of these discount cards into account.

The French Railways have long issued what are known as half-price cards. These are good either over a single route, or on all the lines of one or three Systems, or else on all French main-line Systems (fig. 376). Each card entitles the holder to travel at half-fare in the class indicated on it and in all lower ones. Members of large families are awarded a further reduction of 20 to 40 per cent when purchasing a third card or others.

In Switzerland, half-price cards are issued for 1, 3, 6 or 12 months. The *International Sleeping Car Co.* also issues half-price cards which concern supplementary fares only, both for individuals, members of the same family, and business associates (2).

The American so-called NICKEL PASS is an outcome of the same idea (fig. 377). It is really an identity card sold for a certain sum, the holder thereafter only paying a nickel for each trip as long as the card is valid. Whereas the price of weekly passes is based on 12 journeys a week, the holder travelling as much as he pleases, the cost to him being bad business unless he uses his pass more than 12 times, the nickel pass which is cheap (and often priced at half the cost of three return journeys), is desirable as soon as the holder has travelled a minimum number of times, which varies of course, according to the price of straight fares and which he can calculate for himself. Here are a few examples (3) :

PRICE FOR ONE ORDINARY TRIP. (Cents).	COST OF NICKEL PASS. (Cents).	Minimum number of journeys that must be made before the cost per trip to the holder is less than the ordinary straight fare.
9 1/2	55	13
9	50	13
8 2/3	40	11
8 1/2	40	11
8 1/3	40	12
8	40	13
7 1/2	30	12
7	25	12
6 2/3	20	12
6 1/2	20	13
6 1/4	15	12
6	15	14
5 1/2	5	11
5 5/9	5	12

The decrease in the price varies beyond this point. The following example ap-

(1) So as to get the public to appreciate the cards, a number of them were given free, photos included; they are now sold on the cars.

(2) 20 p. c. for the second card, 30 p. c. for each card afterwards.

(3) Information supplied by *The Globe Ticket Co. of New England.*

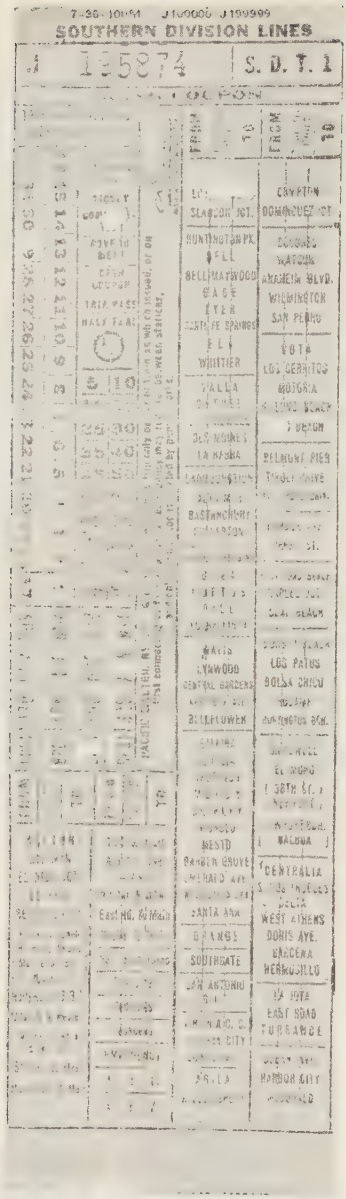


Fig. 375. — Triplex system exchange paper ticket (Red. 3/4) — *Pacific Electric Ry. Co.* — Data in following lists to be punched : Beginning and end of journey, and transfer point; Year, month and day; Class and fare — The fare stage names appear but once, and are punched on the left to show where journey began, in the centre to indicate the transfer point, and on the right for the destination — Month and year of printing form, and number ordered also indicated.

plying to 5-cent nickel-passes with à 6 1/4 fare (1), shows what it comes to :

Number of journeys per week	12	14	16	18	20	22	24
Average fare (in cents)	6.25	6.07	5.93	5.83	5.75	5.68	5.62

The same precautionary measures against fraud are taken for the nickel as for other passes (2).

D. PAYMENT DURING THE JOURNEY.

Tickets are issued en route to meet various requirements. Paper tickets are sold on certain lines with heavy traffic but few stops, as on the original Brussels-Antwerp « bloc » or set trains and, conversely, on lines with poor traffic where trains are worked economically as on lines run on light-railway principles. The former used fixed journey tickets, the latter, variously priced tickets with the lists of all places between which they are available (figs. *94* and 306).

Passengers entering the trains at unstaffed halts are occasionally given Edmondson tickets for the more usual journeys (fig. 303), or series-parameter paper tickets which are quicker to issue and easier to check than blanks *(fig. 217)*. These also are issued by the guard and torn from perforated books; they are duly filled in, the same particulars being reproduced on the counterfoil (fig. 378). Many French tickets of the kind have gummed backs for fixing them to the tickets they complete *(figs. 515, 516)*.

In America, writing is avoided by printing on the cash fare checks lists of factors which the ticket collector punches as required *(figs. 226, 242, 253 to 257)*.

(1) Information supplied by *The Globe Ticket Co. of New England.*

(2) The colours vary on each line, and from one week to another; the passes are printed on special paper (three-ply stock) with the date, a symbol, and safety background.

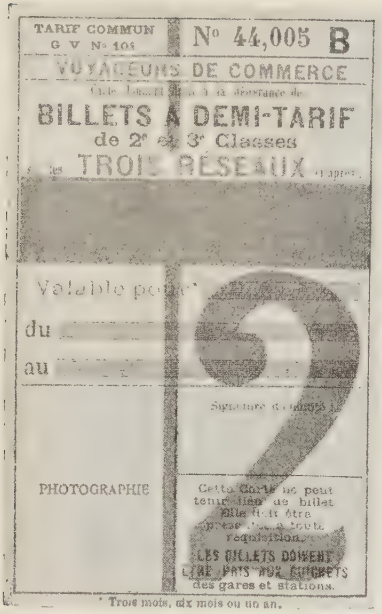


Fig. 376. — Card enabling bearer, a commercial traveller, to purchase tickets at half fare — Available on three French main-line railway Systems (Red. 3/4) — Holder identified by photograph — Class of carriage surcharged.

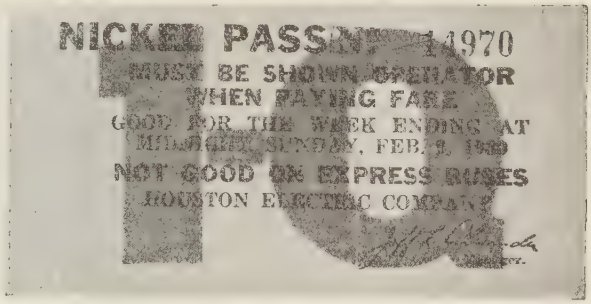


Fig. 377. — Nickel pass card enabling bearer to purchase tickets at a reduced rate (Red. 3/4) — *Houston Electric Co.* — Surcharged with distinctive symbol.

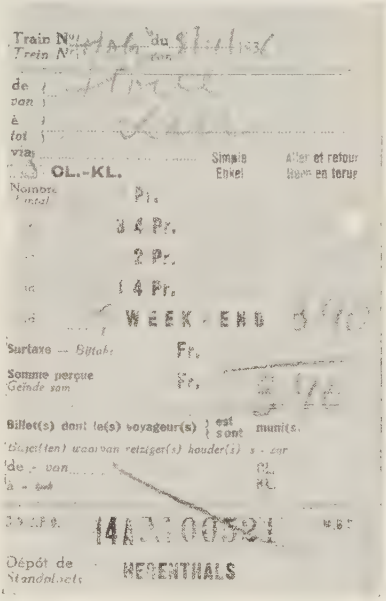


Fig. 378. — Blank paper ticket sold on the trains (Red. 3/4) — *Belgian National Rys. Co.* — Dotted grids for filling in the origin and destination, the class, number of passengers, amount charged for a single or return ticket according to the various reductions.

Whereas the issue of tickets on the trains is exceptional, it is the rule in road transport. According to the density of the traffic and the length of the journeys, different methods ranging from the simple pre-printed ticket to that printed as issued (see part I) are used, an intermediate solution being the partially printed ticket on which the particulars relating to the journey are entered by hand or printed as required (see part G : Checking).

It is sometimes difficult to determine in which Chapter certain matters should most properly be dealt with, as they can be treated under different headings from various standpoints. The tickets under review could have appeared under « blanks », in Chapter VI, in Chapter XV

Fig. 379. — Paper ticket from *Hall Autographic Machine* (Red. 3/4) — Special large hole perforated edges into which a slide's pawls fit for ejection from the machine — Pre-printed serial number and spaces for hand-written data.

Fig. 380. — *Bell Punch Co.*'s « automaticket » and counterfoil (Red. 3/4) — Continuous safety background — Writing transferred by double-faced carbon to the back of the ticket and to the counterfoil — Semi-circular holes to assist the forward movement in the machine.

under « checking » or else in this section, the extra data being entered by means of special appliances. To remain logical, we mention them in Chapters VI and XV, but shall investigate them here where they truly belong.

Autographic machines issue tickets whose indications are completed in writing and transmitted, through a carbon paper or ribbon, onto a blank roll of duplicate paper or a counterfoil which remain in the machine and to which the conductor has no access. The ticket- and parallel duplicate-rolls must revolve synchronously, which is somewhat of a difficulty since their diameters necessarily differ slightly.

These machines are not sufficiently speedy for town service, but may be convenient on long suburban runs.

The **Hall Autographic machine**'s tickets are printed on two ticket rolls, preprinted with spaces for writing in :

The fare;
The class (category);
The date of return;
The point where the car was boarded and quitted;
The conductor's number.

The tickets are continuously numbered

and perforated with relatively large holes so that a slide fitted with pawls can propel them forward when the pawls are engaged in the holes (fig. 379). A carbon ribbon running between two rolls transfers the inscriptions to the surface of the counterfoil roll and the back of the tickets themselves so as to hinder unauthorized alterations.

The conductor traces over the ticket number at each stage. The machine is provided with a punch for punching in a printed list, on the return journey, the time when the ticket was used. When issued as exchanges for returns, a large « X » (exchange) is written on the ticket; the value must correspond with that of the returns collected by the conductor. A counter totalizes the figures inscribed on the duplicate roll.

The **Paragon Register** as used by the *East Kent Road Car Co.* enables all details to be written on the forms, where they are duplicated, triplicated or more and, by turning the handle of the register, the written form (passenger's ticket) and duplicate (confirmation copy) move forward, whereas the bottom copy (audit office duplicate) falls into a locked compartment in the lower part of the machine.

There is no handling of the carbon paper which is coiled at the side of the register. This ensures cleanliness and speeds up operations.

The number of copies that are thus made at the same time varies from two to four or more according to the Companies' accountancy. In the first instance, the top copy is retained, the second goes on record. In the latter, the first copy is a ticket for the outward journey, the second, for the return one, then come the confirmation copy and office record.

The **Portable Automaticket machine** was marketed by the *Bell Punch Co.* so as to provide a more complete system of checking than do printing machines that record totals only instead of amounts collected for each ticket-value issued, which is only possible for a strictly limited number of denominations.

This machine issues tickets of the autographic type, which are franked at issue by the conductor, the machine retaining a duplicate of the ticket. This machine is speedy and simple.

The tickets are pre-printed and serially numbered, and have no value unless completed in writing by the collector (fig. 390).

The writing space from which the ticket is projected when pressing the ejector, is on top of the machine. This writing can only be completed in the ticket-issuing machine, and when so done, the machine duplicates on the back of the ticket, the writing on the front. This duplicate cannot be tampered with.

Further, a duplicate of the ticket can be produced by the machine and remains in it. It is on a continuous strip of stout paper in a form suitable for rapid mechanical analysis. A speed of 150 tickets a minute can be attained.

The tickets are stout card of 2 1/2" by 1 3/4". With their duplicates, they are printed in strip formation and folded in zig-zag, both ends of the bundle being accessible. The duplicate receipt is not produced by carbon papers or ink spools, but by a specially devised duplicating plate. This consists of material in a frame, which material is impregnated with copying ink in three colours : purple, black, red, arranged in bands. It reproduces the operator's mark in the three colours, both on the back of the ticket

and on the duplicate, in a style which cannot be imitated or altered.

The machine, whose dimensions are 7 1/2" by 5 1/2" by 2", weighs 3.3 lb. It is made of steel and duralumin and incased in moulded bakelite. It has a capacity of 500 tickets, without replenishment. It can be supplied with a perforating device, termed the Cancellor and/or a dating device, termed the Code-dater.

Payment of transfers. — Unless a uniform rate with no reductions is in force, transfers cannot be issued free to all passengers. But when there is a uniform rate, differences occur, tramway and trolleybus fares being often cheaper than motorbus ones. To equalize these differences, an extra payment has to be made for transfers, either in the first car, in the second, or in both. As ordinary journeys can be paid for in cash or by tokens, both methods of payment are allowed for paying these supplementary fares.

Here is a fairly comprehensive example relating to the *Indianapolis* services (1) where there are four kinds of transfers :

Omnibus : 10-cent journey; free transfers.

Trams and trolleybuses : 7-cent cash fares (6 3/4 cents in tokens), 2-cent supplement in first car.

Feeder buses : same rates; free transfers to tramways — Free transfers to others buses; formerly, 4-cent supplement in second bus (3 3/4 cents in tokens).

College cars : free transfers from car to car.

Instead of paying 4 cents for bus to bus transfers, 2 cents (or 1 3/4 cents in tokens) is now paid in the first, and as much again in the second bus, except by children who pay the same amount in the first car but nothing in the second.

In *Baltimore*, transfers are subject to similar charges (2). A fare zone overlap check bought in cash or by tokens is good for one journey on a second route. When handed to the conductor with the fare, he issues a county zone ticket instead. Two (successive)-journey tickets are also issued and available for the second journey on payment of 5 cents, half the usual straight fare.

Similar methods apply in Europe; thus a 5-Rpf. supplement is paid in Berlin buses by passengers whose transfers have been issued in trams.

E. PAYMENT AT THE END OF THE JOURNEY.

It previously occurred when extra payments were due and could not be attended to during the journey; ordinary tickets were bought on arrival and cancelled immediately, but now that corridor carriages are so general, payment seldom takes place at the end of a journey.

Partial refunds are made when the Company wants :

(a) To recover tickets which the holder is not obliged to give up;

(b) To check the travelling staff;

(c) To reimburse amounts unduly charged;

(a) By making the ticket holder pay a deposit, the Company induces him to hand in expired season tickets in return for his deposit. The latter is necessarily small for urban season tickets, such as American passes. Instead of selling them

(1) To distinguish the class of transfer at a glance, tramway transfers are printed with the name and symbol of the route in red; transfers issued in buses are similarly marked in green.

(2) *Baltimore United Rys. and Electric Co.*

at 25 cents, 30 cents are charged, it being understood that 5 cents will be refunded on the holder handing over the ticket. This refund takes place in cash or by a 5-cent rebate on the purchase price of any other ticket bought within a given time (fig. 381).

(b) It is necessary, if the Company wants to verify the accuracy of moneys taken in the cars, to check the actual tickets against the auditor's duplicates. With this object in view, an extra checking fee is added to the price of tickets sold in the cars, and this fee is reimbursed to the passenger who hands in at any of the Company's offices within a 90-day time limit on urban lines and less on others (1) the special refund coupon attached to the tickets (2) *(fig. 71)*.

Other Companies bought back their used tickets for cash (3) or agreed to pay over, in exchange, a given percentage of the face value to some charitable institution or other (4) *(figs. 272-273)*.

We shall refer to this point again in Chapter XV under « Checking ».

PITTSBURGH RYS. CO.—HOLIDAY ST. CAR PASS
Good Only on
TUESDAY, MAY 30th, 1933
"Memorial Day"
1933
Punch Out
"NOT GOOD ON BUSES OR TROLLEY CARS"
No. 03502
25 Cents
THIS PASS IS NOT REDEEMABLE
Commercial Manager
THE HOLDER OF THIS PASS MAY RECEIVE A NEW PASS AT FIVE CENTS LESS THAN THE TARIFF PRICE BY SURRENDERING THIS PASS AT THE TIME OF PURCHASE.
PITTSBURGH RAILWAYS CO.

Fig. 381. — One-day season pass entitling holder to a discount of 5 cents when purchasing new pass (Red. 3/4) — *Pittsburgh Rys. Co.* — Pre-printed date — Passenger agent's signature.

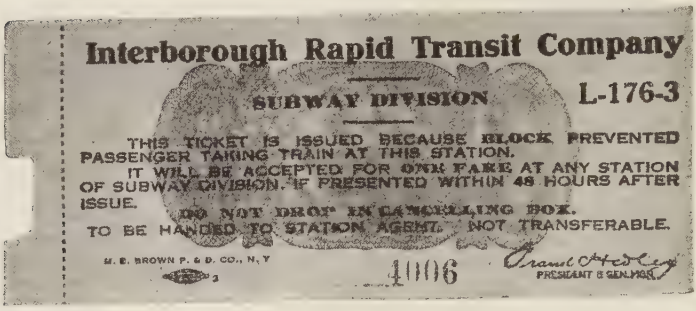
Still other Companies get the same result by making the tickets participate in a lottery or by alloting them some advantage in connection with the winning

(1) *International Co. Buffalo Lockport.*
On the *Grand Valley R. R.*, 10 days only. The rebate is 5 cents in the first car, 10 in the second.

(2) Duplex tickets printed by the *New Jersey International Ticket Co.* included a refund cash fare receipt « redeemable within two days from date of issue from any office, for the difference between the ticket fare from and to stations written in (plus War tax) and the frain fare paid between said stations as shown in dollars and cents at the end of the strip below ».

(3) Companies brought these decisions to their patrons' notice by printing them on the tickets. The *Carris Urbanos*, Rio, worded them :
« The Company buys these tickets (back) on presentation.
The *Rio Grande Co.*, Brazil, did the same.

(4) The *Carris Urbanos* repurchased the tickets for the benefit of a charitable body. A holder could also give them direct to the Asylum of the Good Pastor, or the Gloria Catholic School, Rio. The *C. C. Carris de Ferro*, of Campinas, used to give the Home for the Sick, 5 reis per ticket handed to the Casa Mascotte.
The *Companhia da Viaçao Rio Grandense* paid « the Home for the Poor, or some other work of piety », one per cent of the value of tickets handed to the Santa Casa de la Misericordia (fig. 385).


Interborough Rapid Transit Company
SUBWAY DIVISION
L-176-3
THIS TICKET IS ISSUED BECAUSE BLOCK PREVENTED PASSENGER TAKING TRAIN AT THIS STATION.
IT WILL BE ACCEPTED FOR ONE FARE AT ANY STATION OF SUBWAY DIVISION, IF PRESENTED WITHIN 48 HOURS AFTER ISSUE.
DO NOT DROP IN CANCELLING BOX.
TO BE HANDED TO STATION AGENT. NOT TRANSFERABLE.
M. E. BROWN P. & D. CO., N. Y.
4006
PRESIDENT & GEN. MGR.

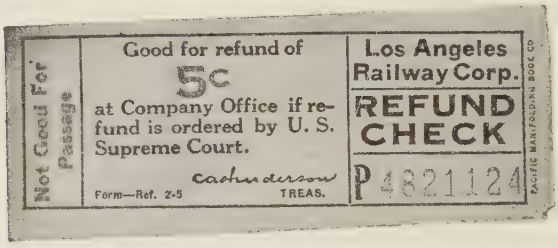


Fig. 382. — Paper ticket issued in the event of a traffic stoppage and available for another journey within 48 hours (Red. 3/4) — *Interborough Rapid Transit Co.* — Intaglio safety background — President's signature stamped on.

Fig. 383. — Conditional refund coupon (Red. 3/4) *Los Angeles Ry. Corp.* — Seven-figure serial number.

number in State lotteries (1) (figs. 384, 385).

(c) In America, refunds of sums incorrectly charged or received by the Companies for services which circumstances prevented them from rendering, are more usual than with us.

When an increase in fares was resisted in the Supreme Court of the United States, each ticket was provided with a coupon for a repayment of possible overcharge in the event of the action being decided against the Companies (2). The time limit for the presentation of this coupon was relatively long.

Another case is that of late arrival of

(1) If the number of a ticket of the *Havana Electric Ry. Co.* is the same as one in the National Lottery drawn on..., the Company will give a whole lottery ticket to the holder of the winning number, a half ticket or 40 free rides to the next, and so on.

Instead of handing 50 Brazilian milreis worth of tickets to a charitable body, the holder can exchange them, in Rio Grande, Brazil, for 1/5th of a State lottery ticket.

The *Companhia Cantareira* used to organise its own lotteries (fig. 384).

(2) The *Wabash Ry. Co.* used to issue on part of its system an : « Illinois Claim Check » bearing the following : « This ticket... the above company agrees to pay... before the... part of the fare for said ticket in excess of present... of statutory maximum charge therefore, if and when it is finally determined by the United States Supreme Court that the reports and order of *Interstate Commerce Commission in Detroit* (No. 8083) under which said ticket was sold, do not justify collecting of such excess ».

crack expresses for which a speed extra-fare has been charged and is no longer justified. All or part of the supplement must be refunded according to the delay (1). This is why the Companies protect themselves to a certain extent, in timing the last lap more leniently.

These refunds are also made by city rapid transit Companies. Thus if a connection is missed owing to a block on the line, the ticket becomes valid for 48 hours for any other journey on the system and to any station whatever (2) (fig. 382).

CHAPTER IX.

MEANS OF PAYMENT.

A. PAYMENT IN CASH OR ITS EQUIVALENT.

This is the most usual case and no comment is needed. It should be pointed out, however, that in order to speed up the service, certain ticket-issuing machines are also change-giving. We shall describe them in Part I (Machines).

B. PAYMENT BY VOUCHER.

Some undertakings sell, at reduced rates, booklets of vouchers which entitle the holder to a ticket, when presenting the vouchers before starting (3). This sets an accountancy problem which has been solved in two ways. The simplest course is to exchange the voucher for a special ticket with which the booking office has to be provided. Another way is to exchange it for an ordinary ticket, the voucher becoming a cash item bearing, apart from its nominal value, the full value of the ticket which is handed out in exchange.

Road transport undertakings have modified this system to suit their particular needs. Besides reduced-fare singles, many of them issue, up to a certain time in the morning, vouchers which have to be exchanged on the return journey; their appearance differs necessarily from that of the other tickets (4).

Booklets of vouchers are also issued to officials of such public bodies as are legally entitled to travel free or at reduced

---

(1) The tickets printed by the *Woodward and Tiernan Printing Co.* of St. Louis, for the journey in the extra fare train No. 2, from Fort Wayne to Philadelphia, carried an identification coupon to be exchanged by the passenger on his arrival against an extra fare refund order issued if there had been a 55- or more minutes delay, and which he handed the ticket agent at the arrival station. The ticket bears a list of hours from 1 to 8, and the following text : « This coupon punched above by conductor to show number of hours late will be authority for ticket agent to make refund within 30-days from date of issue in accordance with tariff ».

(2) *Interborough Rapid Transit Co. Subway Division* (fig. 382) : « This ticket is issued because block prevented passengers taking train at this station. It will be accepted for one fare to any station of subway division if presented within 48 hours after issue ».

The « delay check » of the *Chicago Rapid Transit Co.* is also valid for any journey.

(3) On January 1st. 1857, the former *Compagnie Générale des Omnibus de Londres* started selling bus tickets in packets, with a 10 p. c. discount in the £. The sales in their Strand office reached 10.000 on the first day. Strictly speaking, they were not so much tickets as vouchers of 2 d., 3 d., 4 d., and 6 d. value, but in spite of their elegant engraving, they were soon discontinued.

The French Company was turned into an English undertaking, the *London General Omnibus Co. Ltd.*, on November 16th, 1858.

(4) At *Manchester*, there is space for each day of the week. The spaces are alternatively shown in one of three colours *(fig. 283)*.

200 RS.
Companhia Viação Rio-Grandense
UMA PASSAGEM
CIRCULAR
Os portadores destes coupons na importancia de CINCOENTA MIL RÉIS tem direito a UM QUINTO DE BILHETE DA LOTERIA DO ESTADO entregue no escriptorio desta Empreza. (Veja o verso)

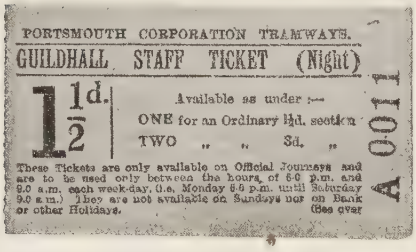

PORTSMOUTH CORPORATION TRAMWAYS.
GUILDHALL STAFF TICKET (Night)
1 1/2 d.
Available as under :—
ONE for an Ordinary Hd. section
TWO " " 3d. "
These Tickets are only available on Official Journeys and are to be used only between the hours of 6.0 p.m. and 9.0 a.m. each week-day, i.e. Monday 6.0 p.m. until Saturday 9.0 a.m.) They are not available on Sundays nor on Bank or other Holidays.
A 0011

Fig. 384. — Ticket participating in a lottery. (Actual size) — *Cantareira and Fluminenses Co.*, Brazil — Illustrated safety background — Arc perforations.

Fig. 385. — A certain number of these tickets handed back to the Company entitle bearer to a fifth part of a State lottery ticket — *Rio Grande Transport Co.*, Brazil (Red. 3/4).

Fig. 386. — Booklet coupon available for one section at specified hours (Red. 3/4) — *Portsmouth Corporation Tramways* — Category : staff only.

rates and tickets of an agreed value are given in exchange (1).

In Holland, Germany, etc., passengers frequently pay for their rides by means of coupons of various denominations and receive instead, countermarks which are actually tickets of corresponding value and only differ from ordinary ones in that the value is nominal instead of actual.

In the United States, the same system is widely used for both rail and road transport, for which booklets of sheets of one-fare coupons are sold to various classes of passenger (figs. 387 to 392) :

Bearers,
Members of the same family,
Children,
Scholars or students,
Company's employees,
Workmen.

Here again, beautiful printing appeared on the older tickets. It was occasionally produced by bank-note printers such as the *Western Bank Note Co.*, Washington (fig. 390), the *Hamilton Bank Note Co.*, New York (fig. 391), etc.

Elementary transport-coupons. — With fare rates based on the distance travelled there is an equivalence for each class of ticket between the distances and the fares; when either is known, the other can be inferred. Series of elementary transport-coupons under the two forms of elementary distance- or elementary value-coupon, either contained in booklets or in sheets, have therefore been sold at a rebate price, the holder having to ex-

(1) The *Portsmouth* Guildhall's vouchers are valid for the staff from 6 p. m. to 9 a. m.

(Footnote continued on opposite page.)

One-fare card coupons (Red. 3/4).

Fig. 387. — Travel-element — *South Washington Ry. Co.* — Lithographed on both sides in red and blue — Picture of the Capitol — Signature.

Fig. 388. — *Mahoning and Shenango Ry. and Light Co.* interurban zone fare ticket.

Fig. 389. — First *Rio Grande Co.*, Brazil, lithographed card coupon.

change the necessary number for the ticket he requires (1).

Elementary distance-coupons. — Many Railways issue booklets containing 500, 1,000, 2,000, 5,000 or 10,000 miles (or kilometres) worth of coupons. So as to reduce the numbers of coupons to be handled, the railways sometimes include coupons of 5- or 10-unit value, besides a large number of single-unit ones. These books are to be found in countries widely separated from each other, from India to America.

Various classes of booklets are issued to

Bearer;
Members of a given family;
Commercial travellers;
Or are personal.

---

each working day. One voucher is collected for a 1 1/2-d. journey and two for a 3-d. journey.

At *Cardiff*, each sheet of the booklets consists of two coupon-vouchers joined on their long side.

The *Birmingham Corporation* issues 1/2-d. coupon booklets.

The *Central S. M. T. Co. Ltd.* (Glasgow), does not issue countermarks to withdraw returns. The conductor effectually prevents their possible use for any other journey by stamping them (as in the « Setright » system) and adding the month, day, route number, etc.

At *Rothesay*, each workman's voucher entitles him to a countermark valid for a double journey. The 1 1/2-d. coupon-vouchers are valid for one journey on one section within 12 months from date of issue.

(1) In England, these are mileage tickets; in the United States, there are even interline mileage checks. In Canada the tickets, printed in two languages, issued in exchange for the coupons in books of 500 to 10 000 miles, are « tickets for journey on mileage basis ».

The shape of the coupons varies. Sheets of them may be bound in books as in South America (fig. 395). In Canada, their appearance is similar to that of the British and continental books of coupons.

In the United States and on other railways where their methods apply, the coupons are printed in two or more colours on long strips of special paper, which are folded zigzag fashion into a thin cardboard folder cover 5 1/4" by 2 3/4" in size, closed with a rubber band (1). The length of the coupon strip, including the two stubs, is often considerable and reaches 10' 6" for 1,000 (2) and 17' for 2,000 miles (3).

Elementary value-coupons, in strips or booklets, are frequent both in the States and elsewhere. The American standardized books are of $ 15, $ 30, and $ 50 worth, each containing a certain number of coupons of 3 cents nominal value, besides 1-cent luggage coupons (4) (fig. 393).

Besides full-fare coupon booklets, other classes are issued :

Advertising scrip books, issued free to advertising bureaux in the district in return for publicity received;

Press scrip books for pressmen, generally valid only in the district where their paper circulates.

The same system applies to payment for the railway's subsidiary services :

Luggage service books, value $ 12.50 or $ 25, in 5-cent coupons;

Lunch tickets in books, value $ 2.50, also in 5-cent coupons;

They are also found on interurban lines, such as the *Illinois Traction System*, which sells $ 10 booklets of 100 coupons. Elsewhere, the sheets of coupons are bound together (fig. 395).

ROAD TRANSPORT ELEMENTARY VALUE-COUPONS. — During rush hours, it is difficult to deal with the traffic, to provide all passengers with tickets and more especially, to give change.

The latter drawback is obviated by various means, all of which seek to induce the prospective passenger to buy tickets in advance, either in bulk or in books of coupons. But when an entire system is involved instead of one line only, the problem assumes a different aspect, as advance tickets may be used anywhere.

They must be checked, and when used for any journey, must be identified with that particular journey, and that one only. This is accomplished by the conductor who overprints them at the time, with the data that apply to it only :

Line;
Stage;
Date and time;
Conductor's number, and so forth.

To do this, a suitable system or style of tickets and machines whose accurate working can be controlled, are required.

The **Klein-Massot cancelling and recording machine** (fig. 397) prints the

(1) These tickets have been standardised. The cover is in thin cardboard, six-ply tough check, and the excellent quality paper used for the tickets, 16-lb. bond.

(2) *Atlanta and West Point R. R.*

(3) Valid on the *Atchison, Topeka and Santa Fe*, and the lines of 21 other Companies.

(4) During the War, the United States Railroad Administration standardized the ticket forms, sizes and material. The cover of the $ 30 scrip books was to be plain white, and that of their coupons bluish white, the cover of the $ 90 books bearing a vertical grey stripe and their coupons, light grey. The cover and coupons for luggage were to be printed in red and green respectively.

Fronts and backs of finely engraved American one-fare coupons (Red. 4/5).

Fig. 390. — *Washington and Georgetown R. R.* — Engraved by the *Western Bank Note Co.* — Company's monogram on back.

Fig. 391. — *New York and Brooklyn Bridge R. R.* — Picture on face.

Fig. 392. — *Brooklyn Union Ferry Co.* — Coupon for foot passenger — Intaglio drawing on back.

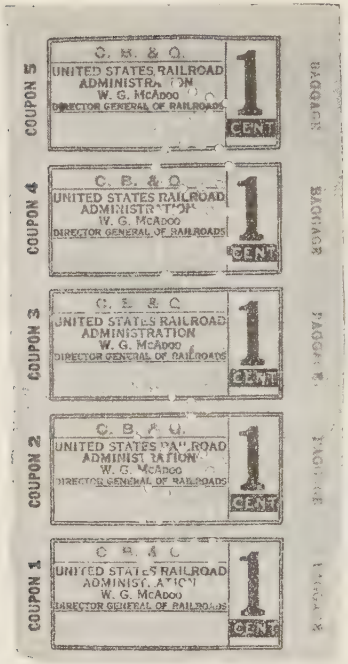
necessary particulars on strips of elementary coupons, whose value is a common divisor of all fare rates. It may be necessary to modify this value as circumstances require.

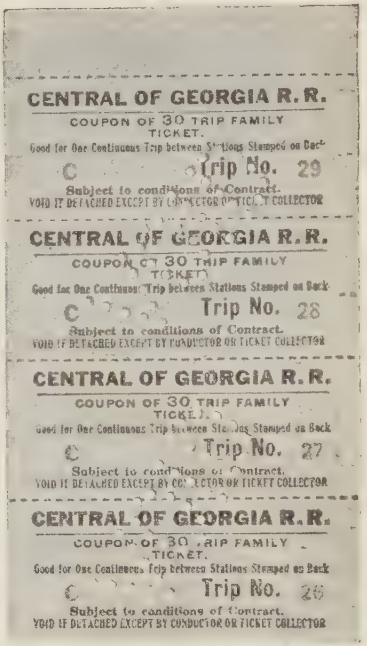
Each coupon represents a definite amount and the passenger tenders as many as are required to make up the total fare. So that their number be not too large, their value is made as high as the fares will permit.

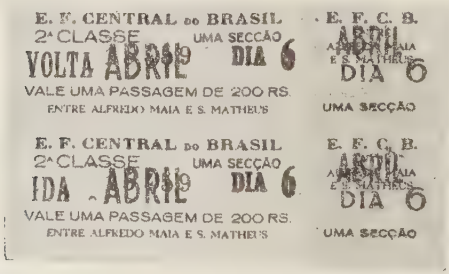
The BOOKLETS OF SHEETS OF COUPONS (figs. 400-402) are sold in advance for round sums; if any change giving is needed, it takes place once for the entire booklet instead of on every trip. The passenger thus enters into possession of a number of elementary value-coupons with which he can purchase transport. To avoid fraud, these coupons are very carefully printed with lithograph colour designs, with the number of the booklet and with their own serial number in it. There is also a safety background which usually consists in the repetition of the Company's name in small type (figs. 401, 402). One or two colours may be used (1).

The CANCELLING OF THE VALUE-COUPONS en route converts them from paper-currency into tickets and, having associated

(1) Waved parallel lines on the *Autotransports Ardennais*.




CENTRAL OF GEORGIA R.R.
COUPON OF 30 TRIP FAMILY TICKET.
Good for One Continuous Trip between Stations Stamped on Back
Trip No. 29
Subject to conditions of Contract.
VOID IF DETACHED EXCEPT BY CONDUCTOR OR TICKET COLLECTOR
CENTRAL OF GEORGIA R.R.
COUPON OF 30 TRIP FAMILY TICKET.
Good for One Continuous Trip between Stations Stamped on Back
Trip No. 28
Subject to conditions of Contract.
VOID IF DETACHED EXCEPT BY CONDUCTOR OR TICKET COLLECTOR
CENTRAL OF GEORGIA R.R.
COUPON OF 30 TRIP FAMILY TICKET.
Good for One Continuous Trip between Stations Stamped on Back
Trip No. 27
Subject to conditions of Contract.
VOID IF DETACHED EXCEPT BY CONDUCTOR OR TICKET COLLECTOR
CENTRAL OF GEORGIA R.R.
COUPON OF 30 TRIP FAMILY TICKET.
Good for One Continuous Trip between Stations Stamped on Back
Trip No. 26
Subject to conditions of Contract.
VOID IF DETACHED EXCEPT BY CONDUCTOR OR TICKET COLLECTOR



Strips of coupons (Red. 3/4)

Fig. 393. — Sheet of luggage 1-cent coupons — United States R. R. Administration of the *Chicago, Burlington and Quincy.*

Fig. 394. — Sheet of family 30-trip coupons — *Central of Georgia R. R.*

Fig. 395. — Part of sheet of strip coupons for specified journey — *Central Ry. of Brazil* — Three-colour printing — Outward and return journeys alternated.

them with a particular journey, makes them subsequently valueless for any other.

The machine prints simultaneously in several rows on all the coupons of a strip, but certain particulars are only printed on the first one.

Two figures are printed on the first

line on each coupon, the first indicating the stage point where the passenger boarded the car, the second where he alights, together with a very distinct symbol applying to the latter. Below, on a second line, the number of the machine is printed on each coupon, and finally, on a third line, two figures followed by a letter. The figures denote the month, the letters, the journey or the time. In the case of 1st-class coupons, the machine prints « 1st-cl. » on the first coupon and the remaining particulars on the others. As the value of an elementary coupon has been chosen so as to be the same as the fixed difference between the 1st and 2nd-class rates, there is no need to repeat the wording « 1st cl. » on the following coupons whose number is the same whether the journey take place in 1st or in 2nd class.

The following conventional signs are used :

First stage : a horizontal stroke;
Second do. : two horizontal strokes;
Third do. : three horizontal strokes;
Fourth do. : a large 0;
Fifth do. : a large V.

HIGHER RATE FOR FARES COLLECTED IN THE CARS. — In order to discourage purchasing tickets en route, coupon holders travel at a cheaper rate than do others who are given differently coloured coupons which the conductor takes from a higher priced roll. Obviously, the cost of each coupon must be equal at least to the lowest monetary unit such as a sou (5 centimes), in France.

If the rate for booklet holders is :

2 × 25 centimes (50 c.) for one section;
3 × 25 centimes (75 c.) for two sections;
4 × 25 centimes (100 c.) for three sections;

then the coupon unit-value bought in the car must be 25 centimes + a sou (5 cen-

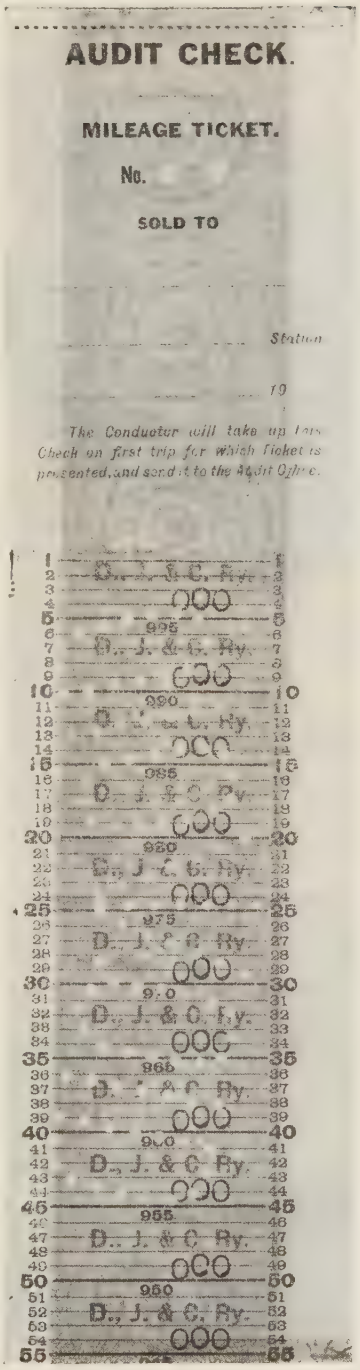

AUDIT CHECK.
MILEAGE TICKET.
No.
SOLD TO
Station
19
The Conductor will take up this Check on first trip for which Ticket is presented, and send it to the Audit Office.
D., J. & C. Ry.

Fig. 396. — Lower portion of an American strip of mileage ticket coupons (Red. 3/4) — *Detroit, Jackson and Chicago Ry.* — Company's name in red — Guilloche safety azure background — On the cover, list of years, months and days to be punched.

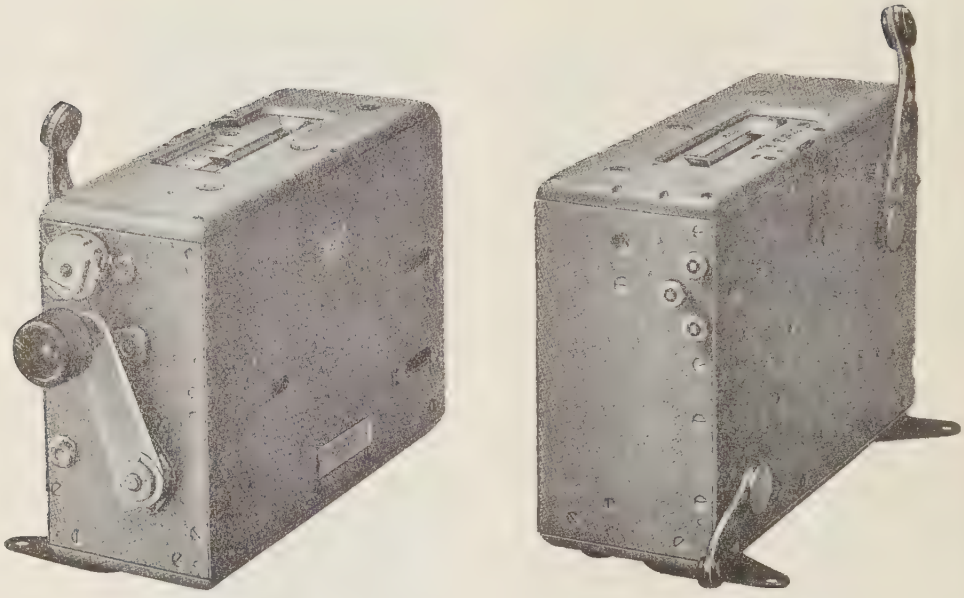


Fig. 397. — The *C. A. M. P.* « Klein-Massot » cancelling and recording machine for use with coupon value-elements — *Société des Transports en Commun de la Région parisienne.*

times) = 30 centimes, and the respective fares become :

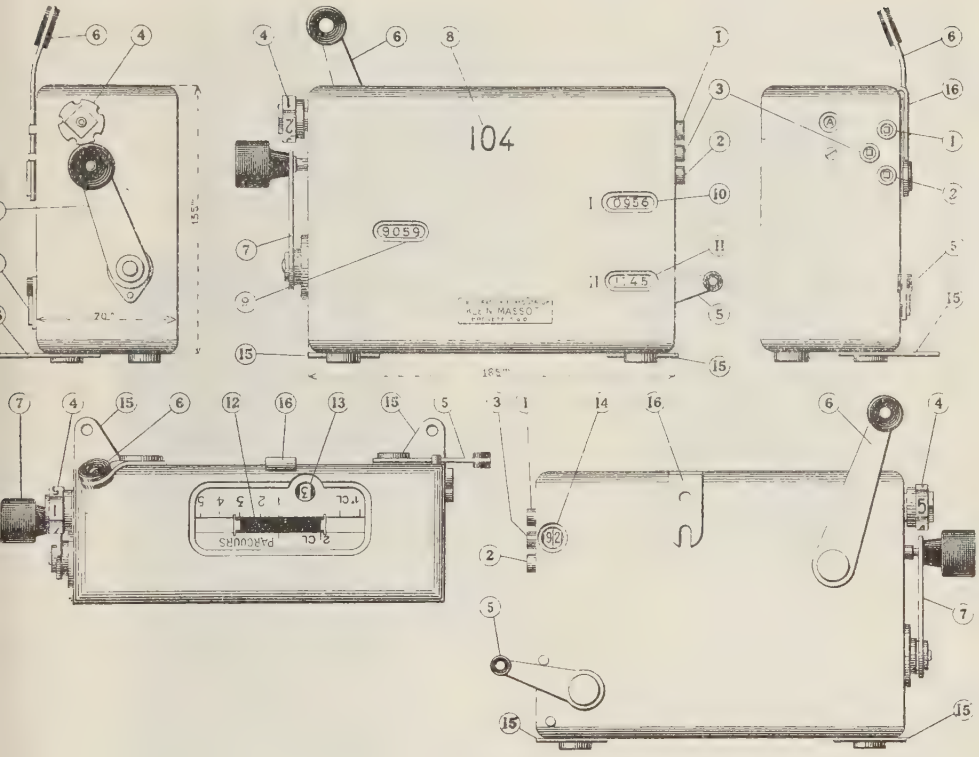
2 × 30 centimes (60 c.) for one section;
3 × 30 centimes (90 c.) for two sections;
4 × 30 centimes (1.20 fr.) for three sections.

DIVISION INTO SECTIONS. — The routes being divided into a variable number of sections, each coupon represents the fare for one section; n coupons are thus necessary for n sections, plus a constant a as a basis (for general service charges). This constant may be of any value and may even be nil.

Several Companies have degressive fares. The *Société des Transports en commun de la Région parisienne* (T.C.R.P.), for example, has three rates, the first applying for 1 to 3 sections, the next for 4 to 5, and the third for 6 or 7. The lowest rate (1 coupon for 2nd class, 1 + 1 for 1st class) is thus increased by one coupon, the second by two, and the last by 3, and so on, as the case may be.

REDUCED-FARE PASSENGERS. — When special classes of passengers enjoy reduced fare (workmen, scholars, cripples, night passengers, passengers with luggage, etc.) books of coupons of different values are used, some of them at certain hours of the day only. The same number of coupons is always detached in the same class for the same journey, whatever the rate, but the coupons are taken as required, from different reels.

As the machine supplies a statistical record of the coupons delivered by the conductor, it is advisable to use the same rates, hence the same booklets, for all different classes (categories) of reduced fares. Differently printed coupons de-



LEGEND :

1. Spindle of disc for printing the day of the month (tens).
2. Spindle of disc for printing the day of the month (units).
3. Spindle of the disc for printing route symbol.
4. Knob indicating where passenger boards vehicle.
5. Lever indicating the class passenger travels in.
6. Lever indicating number of sections to be travelled.
7. Operating handle.
8. Number of the machine.
9. Ticket counter.
10. Counter recording number of 1st-class passengers.
11. » » » of 2nd-class »
12. Slot for insertion of tickets.
13. Indicator showing the point where passenger is to alight.
14. Indicator showing the day of the month.
15. Supporting brackets for attaching to base plate.
16. Supporting hook for attaching to base plate.

Fig. 398. — Details of « Klein-Massot » apparatus.

ivered to various classes of passengers allow of easy identification during the ourney, and yet require but a single re-ord.

When there are but few stages, the ma-hine cancels up to three different fare ates, but should there be more stages, hese rates become complicated and one nly can be dealt with. The machine can lso be provided with a cancellor for unching holes in special kinds of ti-kets, such as seasons.

The machine is usually carried on a harness. There is no objection, when fitted to the car, to its being made to cope with further requirements even should this make it larger and heavier. It may be operated by an electric motor.

CHECKING TRANSFERS. — The time of cancellation may take the place of the route service number.

DESCRIPTION OF THE MACHINE (fig. 398). On the outside of the case there are

On the right hand side :

(7) A handle operating the printer;

(4) A knob indicating the section where the passenger boards the car;

On the left hand side :

(1), *(2)* and *(3)* Small ringed recesses protecting the ends of spindles with which, by means of a common key, the rollers which imprint the day of the month on the coupon can be set. (The two engraved discs are each numbered 0 to 9).

An indicator showing the route service letter.

On the front :

(8) The number of the machine;

(10) Indicator showing the number of 1st-class passengers carried;

(11) A similar indicator for the 2nd class;

(9) Indicator showing the total number of coupons cancelled;

On the rear face :

(6) Handle, whose position varies with the number of stages the passenger travels;

(5) Handle occupying one of two positions, one when 1st, the other 2nd-class tickets;

(16) Supporting bracket;

(14) Indicator showing the day of the month.

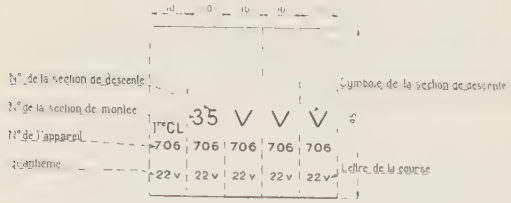


Fig. 399. — Explanation of symbols printed on the tickets by the machine.

Explanation of French terms :

N° de la section de descente = section where passenger alights. — N° de la section de montée = section where passenger boarded vehicle. — N° de l'appareil = No. of machine. — Quantième = day of month. — Symbole de la section de descente = sign indicating section where passenger alights. — Lettre de la course = route designation letter.

On the upper face :

(12) Slot whose length depends on the number of coupons to be cancelled;

(13) Indicator showing the point where the passenger alights;

On the lower face :

(15) Two carrying brackets.

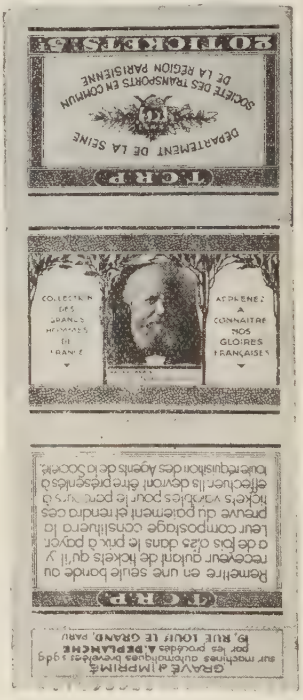
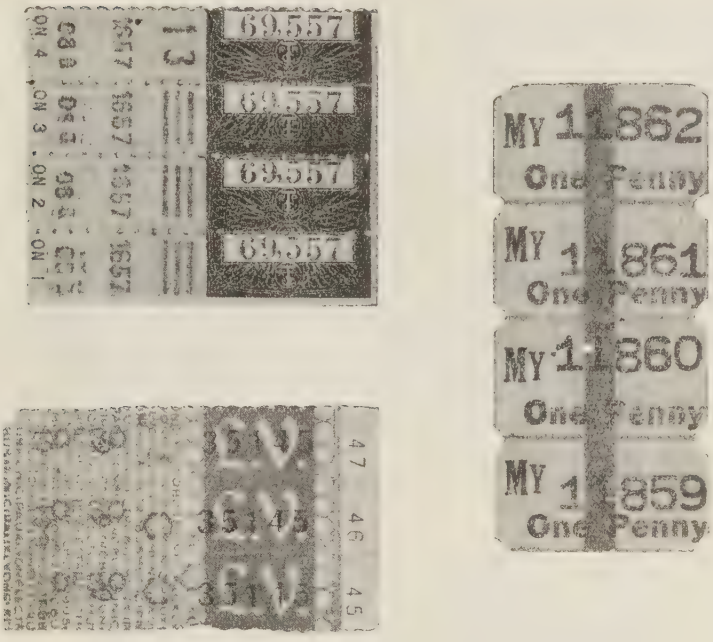

BOTTICKETS
DÉPARTEMENT DE LA SEINE
SOCIÉTÉ DES TRANSPORTS EN COMMUN DE LA RÉGION PARISIENNE
T C R P
COLLECTION DES GRANDS HOMMES DE FRANCE
APPRENEZ A CONNAITRE NOS GLOIRES FRANÇAISES
Remettre en une seule bande ou recevoir autant de tickets qu'il y a de fois 0,25 dans le prix à payer. Leur composition constituera la preuve du paiement et rendra ces tickets valables pour le parcours effectué. Ils devront être présentés à toute réquisition des Agents de la Société.
T C R P
GRAVÉ & IMPRIMÉ
sur machines automatiques brevetées
par les poinçons A. BERLANCHE
5, RUE LOUIS LE GRAND, PARIS

Fig. 400. — Cover of a booklet of « Klein-Massot » value-coupons (Red. 3/4) — Portraits of French celebrities.

OPERATING THE MACHINE. — On starting the machines are adjusted so as to indicate the day of the month by means of a key applied to the spindles *(1)* and *(2)*; *(1)* operates the tens, *(2)* the units. Before leaving the terminus, the route designation letter is changed by means of spindle *(3)*; knob *(4)* relating to the sec-



Value-coupons (Actual size).

Figs. 401 and 402. — Paris transport and *Lyons Municipal Electrobuses* coupons — Bicoloured safety background on the former, single coloured on the latter.

Fig. 403. — English thin card value-coupons.

tion where a passenger boards the vehicle is set so that the figure 1 is on top.

When about to check 2nd-class passengers, the conductor pushes handle *(5)* upwards which is its position for this class. The coupon having been tendered to him, he moves handle *(6)* according to the number of stages the passenger wants to travel. Indicator *(3)* shows where the passenger is to alight and the length slot *(12)* having opened a certain distance tells him how many coupons should be cancelled. The turning of a handle prints (and therefore validates) the coupons which he hands back to the passenger.

When he next enters the 1st class compartment, the conductor lowers handle *(5)* which increases the opened length of slot *(12)* by the size of the extra coupon or coupons corresponding to the fixed difference in price between the two classes.

Whenever another stage is entered, he turns knob *(4)*.

At the end of the day, the statistical details of the number of coupons dealt with and the number of 1st-class and of 2nd-class passengers are all read off on indicators *(9)*, *(10)* and *(11)*.

This is how the system works on a couple of Transport undertakings.

The T. C. R. P., Paris. — So that the cancellor carried by the conductor should

be simple, light and compact, the Company has restricted the number of fare rates. In maintains two classes (1st and 2nd), and has limited the maximum number of stages of any route to 5.

The rates for 1 to 5 sections need 3 to 8 coupons in 1st class, and 2 to 6 in 2nd, including a basis of 2 and 1 coupons respectively to start from.

The machine can cancel up to 8 coupons at a time; it records the total number cancelled, the number of 1st and of 2nd-class passengers. It weighs 4 lb. (1.88 kgr.), being 7 1/4" (185 mm.) long, 2 3/4" (70 mm.) wide and 5 5/16" (135 mm.) high.

At GRENOBLE, books of coupons purchased in advance are sold with a reduction of 20 p. c. on the usual fares. Cripples, members of large families (both at any time of the day), workmen, Company's employees, scholars (all these at certain times only), travel at half-price. The value of the elementary-coupons is 20 centimes in booklets, or 25 when purchased in the cars. There is but one class of travel. Two coupons are cancelled for a two-stage journey, three for more.

The sectioning of the suburban routes is degressive on the basis of 1 to 5 km. (0.62 to 3.1 miles) a section, starting from 35 km. (21.7 miles), so that 16 coupons are needed to pay for a 50-km. (31 miles) run.

Coupons sold in the cars are green, booklet coupons are red, and half-fare ones, maroon.

OTHER UNDERTAKINGS. — These scrip elementary-coupons were first used in Paris. A number of other Companies followed suit (1). The *Liége United Trys. Co.* uses similar, but slightly larger ones.

In England, strips of coupons are also to be met with, but the principle is not the same, hence cancellation differs also. The coupons, which are somewhat larger, have a nominal value of 1 d., occasionally of 1/2 d. each (2) (fig. 403), and the requisite number is detached on each trip, but they are not overprinted in any way so as to identify them with any particular journey.

Cards with elementary-value spaces are sold in Vevey with a 20 p. c. rebate. They have a number of sectional spaces of 5-centime nominal value each, numbered 1 to 50, which correspond to the fare sections (fig. 404).

A single perforation cancels all lower numbered fares.

The method is ingenious, allowing the Company, at it does, to cancel progressive fares at a single cancellation as easily as if uniform fares applied.

Payment by « stamps ». — This very special method of payment is used both by railway and urban transport systems but only, we believe, when paying, in one or several instalments, the price of a series of journeys such as season tickets, etc.

It is used in Belgium for kilometric (mileage) books sold in advance. The stamps taken from them are exchanged at the booking offices for tickets equal in price to their face value (fig. 405).

(1) At Calais, Grenoble, Livry, Lyons *(Electrobus Municipaux)*, *Tramways de Nice et du Littoral* (Nice Division), *Autobus l'Orientale*, Nantes, *(Electrobateaux)*, *Société Versaillaise de Tramways*, *Tramways de Rouen*, *Auto-Transports Ardennais*, *Transports Citroën*, whose elementary coupons are valid for 1-fr. stages.

(2) *Barton lines*, *Potteries Electric* system.

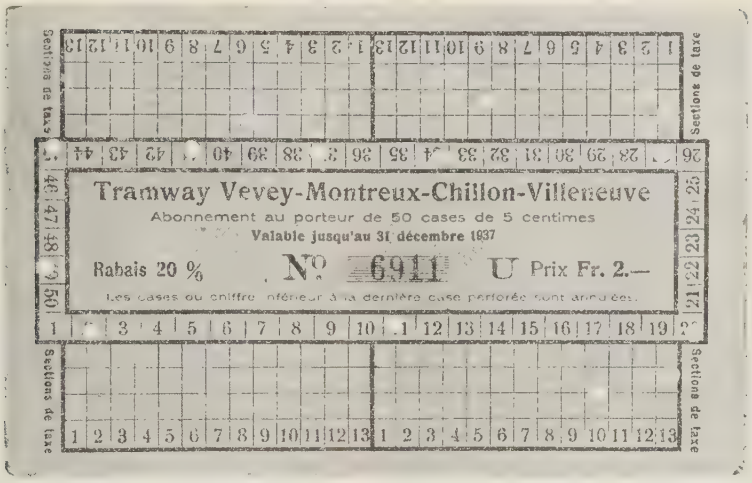

Tramway Vevey-Montreux-Chillon-Villeneuve
Abonnement au porteur de 50 cases de 5 centimes
Valable jusqu'au 31 décembre 1937
Rabais 20 %
N° 6911
U Prix Fr. 2.—
Les cases au chiffre inférieur à la dernière case perforée sont annulées.
Sections de taxe

Fig. 404. — Rebate card with sectional value spaces (Red. 3/4) — *Vevey-Montreux-Chillon-Villeneuve Tramways* — Punching cancels all lower numbers.

Fig. 405. — Sheet of value « stamps » from a 10 000-km. (6 200 miles) booklet (Red. 3/4) — *Belgian National Rys. Co.*

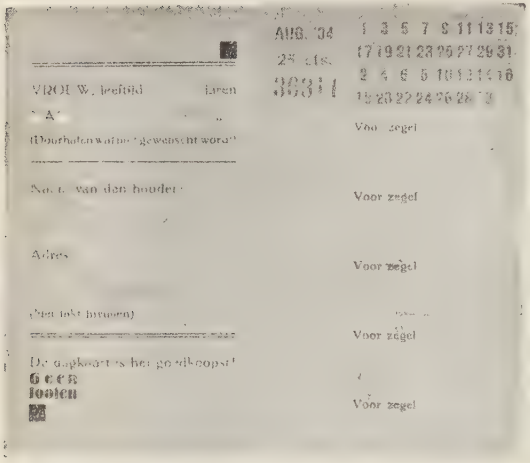


Fig. 406. — Daily season, payment being made by affixing receipt-stamps (Red. 1/2) *Arnhem Municipal Tramways.*

Certain Dutch Companies issue free season ticket blanks provided with spaces for affixing 25-cent stamps sold at the Company's offices (1). All-day free travel is secured after the first conductor has cancelled a stamp stuck on the card (fig. 406).

These stamps are but a means of payment whose purchase power is restricted to the purchase of transport.

C. PAYMENT BY TOKENS.

This method has long been used by transport undertakings. The very first horse-drawn tramways applied it as long ago as 1792 (see p. 270/54), and we have mentioned examples on the very earliest steam railways (2) *(fig. 130)*. Tokens have gradually been abandoned but were re-introduced in the late eighties by the tramway Companies. They sold in advance at bargain rates, rolls of celluloid (3) (figs. *41 to 44* and 407), or light metal tokens (4) whose nominal value corresponded to the fares. Not only did the public appreciate this facility, but these

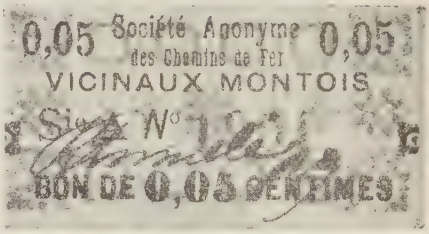


Fig. 407. — 1/2 d. early celluloid token (Actual size) issued by *London County Council Tramways Dept.* in 1889 — Hole in centre.

Fig. 408. — White-metal token issued by the *Indianapolis St. Ry. Co.*, United States — Available for one fare — With holes (Actual size).

Fig. 409. — Card token, value 5 centimes, issued during the War, owing to shortage of bullion, by the *Mons District Light Rys.* (Actual size) — Safety background.

(1) At *Arnhem.*
(2) *London and Greenwich Ry.*, 1837.
(3) See pages 243/27 and 244/28.
(4) Pages 270/54 and following.

light, clean tokens were preferred to the dirty and bulky coppers, even if these happened to be handy when they were needed. Owing to the dearth of small coin during the World War, card cou-

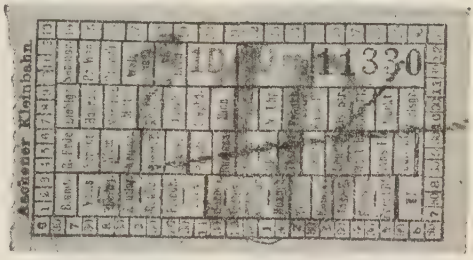
1re Classe Maison de l'Empereur.
Service du Grand-Ecuyer
Voyage de Compiègne
Billet au contrôle
avant le départ
Bon pour une place sur la ligne du Chemin de fer
de Paris à Compiègne
Le Général Premier-Ecuyer,
Aide de Camp de l'Empereur

Fig. 410. — Warrant card good for a journey between Paris and the Emperor's seat (Red. 1/2) — Issued by the Lord High Chamberlain's Office, French Second Empire — Bears the Emperor's crest.

pons and tokens, both circular and rectangular, appeared (fig. 409).

Even now, the use of white-metal tokens is very general in the States, and metal tokens are occasionally to be found in Europe as well (1).

Certain Companies had special tokens made for persons entitled to use them *(figs. 134 to 136)* (2), and issued special countermarks against them.



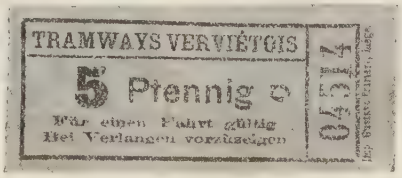


Fig. 411. — Ticket surcharged with transport tax stamp (Red. 3/4) — Belgian bus services.

Fig. 412. — Ticket issued during the inflation and surcharged with a figure without indication of currency unit (Red. 3/4) — *Aix-la-Chapelle Light Rys.* — Lists of days, hours, and half-hours.

Fig. 413. — Value given in currency of Power in occupation (Red. 3/4) — *Verviers Tramways.*

D. PAYMENT BY WARRANTS.

As it is not possible to supply the staff with information on the Company's current accounts, all that is done is to send lists of concerns whose requisition or-

(1) Brass tokens are used in Budapest for short trips and are available in special cars or special compartments of ordinary cars marked accordingly, whilst paper tickets serve other purposes. The tokens are collected when boarding the cars; if a further section is travelled, another token is thrown into a collector box, a bell ringing each time. These tokens are on sale everywhere, and no « K » car can be boarded without them. When necessary, further issues take place, as happened in 1933 and 1936.

(2) *Bradford Corporation.*

(3) *Tramways de Nice et du Littoral (fig. 141).*

00671
S. G. T. D. (Seine et Oise)
Le prix le plus élevé indique la destination et la valeur
Prix :
Chiffres réservés au Contrôle
4 25
Bt 4.25 Bx 75c
4 50
Bt 4.50 Bx 50c
4 75
Bt 4.75 Bx 25c
5 00
A joindre au bordereau avec s'il y a lieu, les coupons de déduire adhérents, dont seul le plus élevé est à déduire du décompte.
00671
A la sortie jeter dans la Boîte
NORD-SUD
109-A
Garantie contre les accidents
VALABLE POUR UN SEUL TRAJET
1re Classe
27412

A-T-A-G - ROMA
Cent.
30
Conservare il biglietto e presentarlo aperto ad ogni richiesta del personale.
Domenicale Cent. 35
27491
S. A. Cesticilono - Napoli - Tel. 26139

Fig. 414. — Duplex ticket from the *Numerus Co.*'s « Controlex » machine (Red. 3/4) — Interperforated fare scale and supplementary values to facilitate checking — Special machine stub perforation.

Fig. 415. — Envelope for tickets, Paris *Nord-Sud* Underground Ry. (Red. 3/4).

Fig. 416. — Ticket with two fares, one for week days, the other for Sundays and public holidays (Red. 3/4) — *A. T. A. G.*, Rome — Three serial numbers — Company's coat of arms.

ders may be honoured. These are chiefly State or Municipal administrations, other Transport Companies or Railway Agencies. Whether the tickets they are to issue come under the Company's full-fare or reduced rates, or are even to be issued free, is stated on the warrants. The only point that concerns us here is that actual tickets can be so issued (fig. 410).

On acceptance of the order, the railway clerk issues the tickets against the warrant, the reduced rate to be applied, if any, having been stated on the warrant.

The French Companies have special printed forms for the more usual reductions such as special single or return journey warrants at half-rate or at military transport rate, etc.

CHAPTER X.

ACTUAL PAYMENT.

1. Fares. — INDICATION OF THE FARE ON tickets is usual, but this is not a hard and fast rule. After having appeared on the earliest railway paper tickets *(figs 56-184)*, and occasionally on the first Edmondsons, they soon disappeared *(figs 54-57)*. Towards 1852, the *North Eastern Ry.*, then the *London and South Western* again printed the fare on their tickets but it was only in 1890 that it became obligatory to do so.

Even nowadays, the fare is not stated on all tickets. This is the case when prices fluctuate with the exchange rate, and with blank tickets whose price differs according to the use they are put to, and which have to be filled in by hand.

A few early tramway paper tickets showed the fare based on a multiple o

the unit rate (1). Others quote extra toll fares (2) which railways usually include, as they do landing fares, in the total price they request.

To avoid the handling of small change, calculated fares are usually made up to round figures, but even this is not always the case and curious fractional values are occasionally to be met with, particularly on road transport tickets, such as 8 and 16 centimes on the original *Liége Tramways*, 12 centimes in *Louvain* and, at the present time, some quite peculiar values in books of coupons issued at reduced rates, such as 16 2/3 pfennig at Frankfort and 3/4 d. at Bridgeford.

The War and military occupation necessarily caused monetary upheavals. Figures *78* and 413 show a Belgian Edmondson railway ticket and a *Verviers Tramways* paper one, with fares in German currency; figure 412, an inflation overprint, without any designation of currency, and figure *505*, a Viennese tramway ticket whose 20 or 30 groschen had become 1 500 crowns.

Curiously enough, certain Swiss tickets still quote currency in rappen instead of centimes, which have long taken their place (3).

Several fares on one ticket. — The most common occurrence concerns the so-called Belgian method of Edmondson half-fare tickets, which can be issued in two portions for children. Each of them bears, besides full fare, the reduced price at which it can also be sold *(figs. 194-201)*.

Elsewhere, other expedients are used, all of which mutilate the ticket in some way which reduces its size and makes fraud impossible. In England, segments of the lower portion are punched out *(figs. 165, 236* and *237)*. In America, the paper tickets nearly all have a space marked « child » or « half rate », which has to be punched when the ticket is issued at 1/2 fare (fig. 254).

In other cases, particularly with road services, the Companies charge increased fares on Sundays and public holidays. When the same tickets are used, both fares are printed on them (4) (fig. 416). This does not complicate the accountancy, which is based on the numbering of the tickets.

There are also, as we have seen, tickets bearing a list of possible fares from among which the one applying to any given journey has to be selected. This is done by perforation, or division of the ticket between two fare marks (« talon-valeurs » = value-scale ticket stub, pp. 508/100 *et seq.*

This method is sometimes used in conjunction with the former; the fare list then comprises a series of double values, each showing the fare to be charged on weekdays and on Sundays (fig. 414).

Similar lists appear on Italian Edmondson and paper tickets, the two series of fares applying to alternative starting places, or concerning different tariffs.

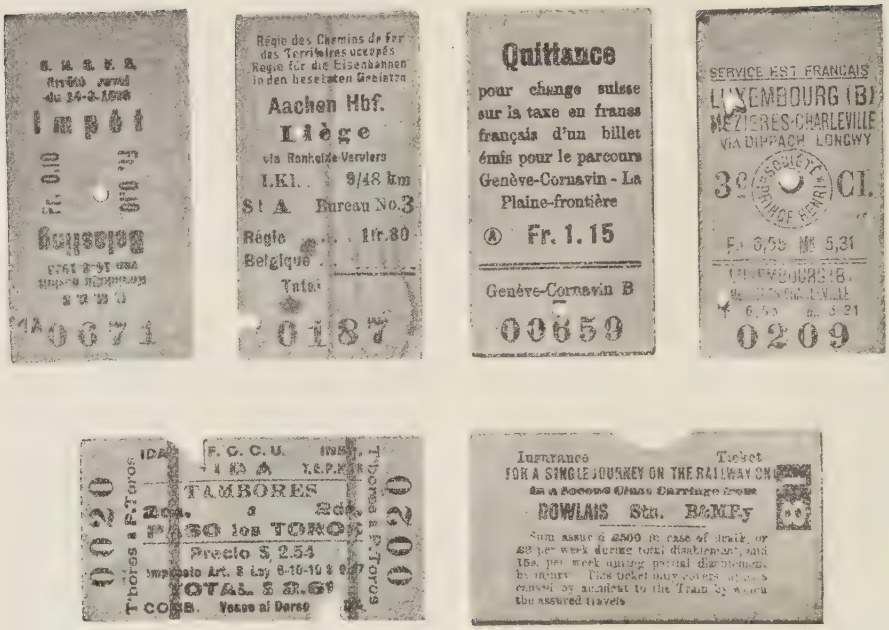
Price or fare alterations. — It is wasteful to have to destroy the stock of

(1) At Hamburg-Altona, « twice 5 = 10 pfennig » *(Centralbahn Ges.)*.

(2) Liége tickets of 1880 used to cost 8 centimes for a 1-km. ride plus 3 centimes toll for crossing the Boverie bridge. This supplement was shown on the back.

(3) *Swiss Federal Rys. (fig. 269); Lucerne Tramways.*

(4) At Lyons : 10 centimes during the week, 15 on Sundays and public holidays. At Milan 5 and 10 centesimi. The lower fare was also charged during certain hours of the day, the cars in which it applied being specially marked.



Various Edmondson tickets (Red. 4/5).

Fig. 417. — Special tax ticket — *Belgian National Rys. Co.*

Fig. 418. — Through ticket showing portion of fare apportioned to each of the Railway Administrations and distance travelled on each — Company's name in two languages — Red stripe signifying, according to the « International Convention » : « good for all trains ».

Fig. 419. — Receipt for Swiss exchange payment covering fare paid in French francs.

Fig. 420. — Ticket with fare stated in two currencies — French francs and equivalent marks — One of special trough tickets issued for each foreign system — Hole and Company's name in centre — Detachable stub including repetition of fare for use when issued to a child.

Fig. 421. — Subdivision of price showing apportionment to Railway Company and Government — *Central of Uruguay Ry.*

Fig. 422. — Insurance ticket. *Brecon and Merthyr Ry.*, Wales — Circular segment punched out of upper border to distinguish it from the others.

tickets in hand when fares are changed. Their nominal value is accordingly altered by overprinting, perforation, or some conventional sign which will show the passenger that a change, whose particulars are posted up in the cars or at the stations, has taken place.

Continental Road Transport Companies often punch the tickets with a star, or cut off a corner, or otherwise mutilate them when fares are changed. The French *Est Ry.* printed a clover or shamrock on them for the same purpose.

It is advisable, when fares are altered, that the passenger should know that the Company is within its rights when re-

quiring him to pay a different price to that appearing on the tickets. A statement such as « relèvement compris » or « R. C. » in France (1) or « revised rate » in England, is frequently added to the letterpress. As with its overprinted tickets, the *Est*'s shamrock is printed on some of its tickets (fig. 651).

Variable fares according to traffic results are applied by the *Portuguese Northern Ry.* since August, 1937, to its weekly workmen's tickets. It hit on the ingenious plan of using part of the increase in receipts from tickets sold in the preceding week to pay the holders a bonus. This incited them to remain faithful to the Company and even to try and entice their fellow workers away from the road transport competing services, so that the sale of tickets should increase and they should get a larger bonus.

When sales rose, the receipts *R* from weekly tickets sold at any given station also increased; the Company was satisfied with retaining a part of this increase $\left(\frac{1}{m}R\right)$, leaving $\left(\frac{m-1}{m}\right)$ R for the patrons. In this way past takings are maintained with the prospect of seeing them improve.

The value m was fixed at 2 (half the increase of the receipts). The price of the tickets p would be brought to p', these elements being connected by the formula :

$$(N + n)p' = (N + 0.5n)p$$

in which :

N, is the number of passengers before the introduction of the system;

n, the number recorded during the week;

p', the price of the ticket which has to be determined;

p, the basic price according to the original rate.

The new price of the ticket is then given by the formula (2) :

$$p' = \frac{N + 0.5\ n}{N + n} \times p.$$

The difference $(p\text{-}p')$ is easily arrived at after the Wednesday of any week. But it is not credited to the passenger until a week of grace has passed; if he ceases to travel by rail he loses the bonus for the last week he travelled by rail, as it is deducted from the price of the ticket for the following week only (3).

A curious fare anomaly can arise from the fact that a nearer station might sell fewer tickets than another further out, and thanks to the bonus the former's ticket would be dearer than the latter's. To avoid this, the stations are grouped in

---

(1) *P. L. M. Ry. (P.* 2. 1936) ; French *Nord Ry.*

(2) In practice, rates are calculated beforehand and give the value of N for each station and values of p' for 6 cases corresponding to 10 p. c. variations from 1.1 N to 1.6 N. The exact values deduced from the formula have been slightly departed from, but not sufficiently to affect results.

(3) The stations exhibit notices showing :
The number of the last ticket sold the previous week;
That of the last one sold during the current week;
The number of tickets sold;
The amount of bonus available for distribution.

The station staff note down the number of tickets sold, with or without bonus, as well as the number of supplementary fares as between authorised workmen's trains arriving at Oporto before 9 a. m. and leaving after 5 p. m. and non-workmen's trains, i. e. the difference, in each case, between the basic rates and the general fare rate.

zones (of two stations each in this instance) for which separate fare scales are used in the calculations, but the number of passengers is totalised. The variation in ticket prices for the stations in one zone is the same as for an isolated station, but it varies with the number of weekly tickets sold by the two stations in that zone (1).

2. **Taxes and dues.** — In many countries, the price of the tickets includes Government taxation. Occasionally, as in Belgium (2) and in Spain (3), special tax tickets were issued by the Railway Companies (fig. 417), for it was decidedly to their advantage to show that part only of the price of the ticket was retained by them. Elsewhere, a notification such as :

« T. C. » (taxe comprise = tax included)

was added (4).

The nature of the taxation may even be specified; thus Uruguyan tickets bear the inscription :

« Tax imposed by law, representing 0.07, total so much » (fig. 421).

Spanish tickets state :

« Fare including 15 p. c. for tax and (duty) stamp ».

And some *Paris-Orléans* tickets were marked :

« Tax of 32.5 p. c. included » (fig. 301).

Several Railway Companies even separate the constituent parts of the amount charged, as 1 fr. 25 + 0 fr. 80 on the French *Est Railway;* in Italy and Brazil so much is specified for the ticket and so much for Government tax (5). Formerly in Russia, as in America during the

(1) The following is a numerical example :

Zone No. 2.	Crestins (10 km. from Oporto) and Pedras Rubras (11 km. from Oporto).			
Quantities.	Crestins.		Pedras Rubras.	
	Price (Escudos).	Value of ticket for following week.	Price (Escudos).	Value of ticket for following week.
Basic number : 130 . . .	10.55	—	11.60	—
Tickets sold :				
143	9.95	0.60	10.95	0.65
156	9.30	1.25	10.25	1.35
169	8.90	1.65	9.75	1.85
182	8.45	2.10	9.30	2.30
195	8.15	2.40	8.95	2.65
208	7.85	2.70	8.60	3.00

(2) A royal decree of March 14th, 1933, imposed a tax of 10 centimes per journey.

(3) In Spain special tickets have been issued for « treasury tax ».

(4) *P. L. M., French Nord Ry., P. O.*, etc.

(5) *Leopoldina Railway Co.*

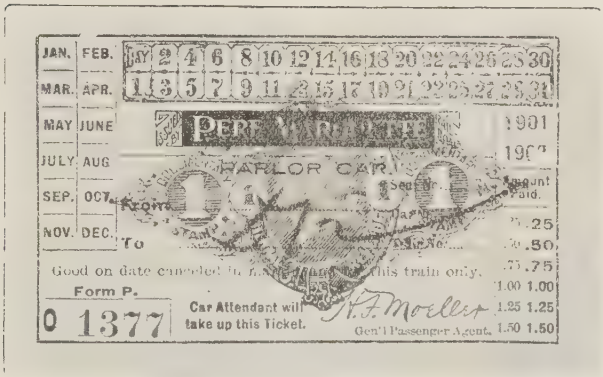


Fig. 423. — Parlour car (saloon) paper ticket (Red. 3/4) — *Pere Marquette R. R.*, United States — Date lists and amount to be collected have to be punched — Printed on paper previously impressed with a State internal revenue documentary stamp.

Fig. 424. — Duty stamp, *Carris de Ferro Co.*, Rio de Janeiro (Red. 3/4).

War, a complete scale of rates and taxes was printed on the tickets *(fig. 257)* (1).

Similarly, certain supplements issued by the *International Sleeping-Car Co.* used to show both the amount of Government taxation and the sum or percentage which had to be handed over to the Railway Company over whose metals the cars ran.

On light railways and road transport lines, the tax is frequently collected before issuance of the tickets; they are surcharged to show it (2) (fig. 411).

Other Companies, who have an account

(1) The duplex tickets supplied by *Poole Bros., of Chicago*, to the *Terre Haute, Indianapolis and Eastern Traction Co.* used to bear a list of the fares in dollars, dimes and cents, with a table of the « War tax schedule » showing the corresponding amount of tax for each fare *(fig. 257)*.

(2) In Belgium, Germany, etc. Such stamps generally have a double circle with inscribed text surrounding the Belgian lion or the German eagle.
They are also to be met with on some mountain lines, such as the *Malbergbahn*.
At Frankfort the tax was 10 pfennig per ticket.

with the public treasury, make advance deposit payments and state so on their tickets (1) (fig. 526).

RECEIPT STAMPS. — In addition to the transport tax, tickets are liable in many countries to a stamp duty. Adhesive stamps must sometimes be affixed, either before or after printing, the former process being used in the United States, the latter in Newfoundland (figs. 423, 297), Italy, Austria and Rumania, where the stamp is stuck on when the ticket is being issued. A fixed duty is generally charged on free passes (2). Many French Railway tickets bore the words « (duty) stamp included ».

3. **Rates of exchange.** — One of the most important of the pecuniary questions is that which concerns rates of exchange. International tickets have avoided it when they have been able to, stating separately the distances travelled on the home Company's lines and on each of the foreign ones (fig. 418), and the fare accruing from each of them.

When exchange was stable, it was possible to pay at will for a railway ticket (3), and even some light railway ones (4), in the currency of any of the countries passed through. The amount to be charged was sometimes shown in two of the currencies (fig. 420), or else in one of them only with a rider stating that the fare could alternatively be paid in the other (5). This was no longer possible when rates of exchange became liable to sudden or frequent fluctuations.

In pre-War years, Brazilian fares were frequently based on the owning foreign Company's currency and were changed for each penny variation of the milreis, whose sterling exchange was taken as basis. To avoid frequent alterations of fares, the staff were provided with complete tables of rates for each of the more usual sterling values of the milreis. No prices appeared on the tickets, but patrons might check prices in fares lists which the station authorities placed at their disposal.

Since the Armistice, similar methods have had to be adopted elsewhere. The *International Sleeping-Car Co.*, for example, still shows on the supplements issued in some of its trains (6) a double entry table giving the fares to be charged between all the stations served, but no fares are now printed in them (fig. 426). The conductor writes in the sum he collects, taking the rate of exchange into account.

So too, certain Administrations issue special tickets to rectify the effects of the exchange. The *Swiss Federal Rys.* issued Edmondson receipt tickets for the fare in French francs from Geneva (Cornavin, the P. L. M. station), to the La Plaine (frontier) station. The rates of this section of Swiss line, worked by the (French) *P. L. M. Railway* were esta-

(1) *Transports Citroën.*

(2) For example in Italy, 0.75 lira for 3rd class on a free pass up to 150 km. (93 miles).

(3) Old tickets of the Ostend-Dover route.

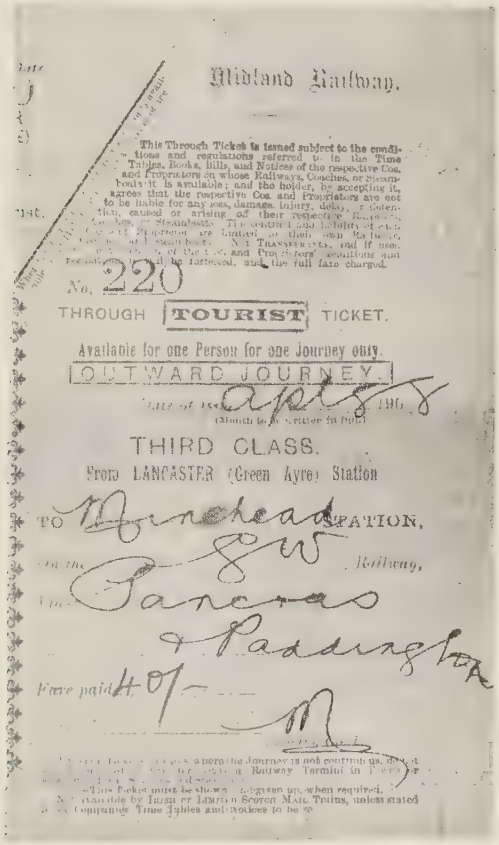
(4) On the line from Schoondijke to the Belgian frontier, where the tickets stated that the franc was taken at 47 cents. In the triangular table of values, 10 centimes was given as equivalent to 4 cents.

(5) The old *Alsace-Lorraine* tickets shew the fares in marks. On the cession of the territory, francs were substituted.

(6) The « Blue-Bird » and the « North Star ».

blished at that time in French francs, although the Swiss fares which obtained on all railways of the Confederation applied; the special tickets we are dealing with were the means of arranging matters.

In Hungary, there is a difference between the internal and external rates of exchange, resulting in a serious disadvantage to the Hungarian railways when international ticket matters are being adjusted. To avoid this, a special coupon is included in the books of combined coupons giving the percentages to be added to the rates of the exchange of each country concerned; this extra sum, paid


Midland Railway.

This Through Ticket is issued subject to the conditions and regulations referred to in the Time Tables, Books, bills, and Notices of the respective Cos. and Proprietors on whose Railways, Coaches, or Steamboats it is available; and the holder, by accepting it, agrees that the respective Cos. and Proprietors are not to be liable for any loss, damage, injury, delay, or detention, caused or arising of their respective Railways, Coaches, or Steamboats. The extent and liability of each Company or Proprietor are limited to their own Railways, Coaches, or Steamboats. NO TRANSFERS, and if used by any of the Cos. and Proprietors' conditions and regulations will be enforced, and the full fare charged.

No. 220

THROUGH TOURIST TICKET.

Available for one Person for one Journey only.

OUTWARD JOURNEY

Date of issue April 8 1938

(Month to be written in full)

THIRD CLASS.

From LANCASTER (Green Ayre) Station

TO Morecambe STATION,

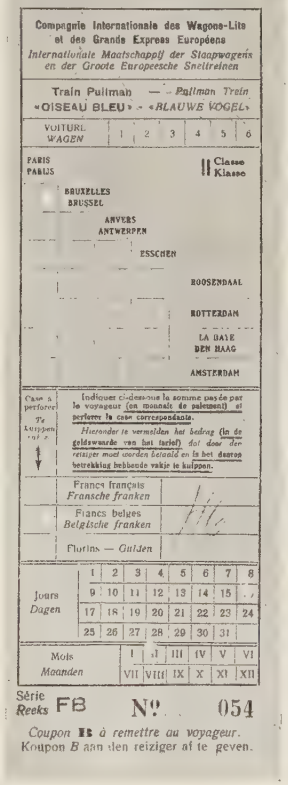
via the Midland Railway,

thence Lancaster & Paddington

Fare paid 40/-

This Ticket must be shown to any person who may require it.

Not transferable by Irish or Limited Scotch Mail Trains, unless stated in the Company's Time Tables and Notices to be so.


Compagnie Internationale des Wagons-Lits et des Grands Express Européens

Internationale Maatschappij der Slaapwagens en der Groote Europeesche Sneltreinen

Train Pullman — Pullman Train

«OISEAU BLEU» - «BLAUWE VOGEL»

VOITURE WAGEN 1 2 3 4 5 6

PARIS PARIJS — II Classe Klasse

BRUXELLES BRUSSEL

ANVERS ANTWERPEN

ESSCHEN

ROOSENDAAL

ROTTERDAM

LA HAYE DEN HAAG

AMSTERDAM

Case à perforer Te knippen

Indiquer ci-dessous la somme payée par le voyageur (en monnaie de paiement) et perforer la case correspondante.

Hieronder te vermelden het bedrag (in de geldswaarde van het tarief) dat door den reiziger moet worden betaald en in het daarop betrekking hebbende vakje te knippen.

Francs français Franssche franken

Francs belges Belgische franken

Florins — Gulden

Jours Dagen: 1 2 3 4 5 6 7 8 / 9 10 11 12 13 14 15 / 17 18 19 20 21 22 23 24 / 25 26 27 28 29 30 31

Mois Maanden: I II III IV V VI / VII VIII IX X XI XII

Série Reeks FB N° 054

Coupon B à remettre au voyageur.
Koupon B aan den reiziger af te geven.

Fig. 425. — Outward portion of blank through tourist return, issued by the *Midland Ry.* (Red. 3/4) — Triangular coupon to be punched out when used for children.

Fig. 426. — *International Sleeping-Car Co.*'s supplement paper ticket for « de luxe » train (Red. 1/2) — With double-entry table of fares (left out) showing supplements to be charged between the various localities served — The number of the car, the journey made, the currency used for payment, the month (in Roman figures) and date are all shown by perforation.

by the passenger when buying his ticket, is credited when the adjustment is made, thus allowing the Hungarian railways, without loss to themselves, to settle the amounts due to foreign lines.

The *Association for the Issue of Combined Coupons* formerly quoted the rate of exchange applicable to the various Administrations on the franc-basis. The rate of a currency, in gold-francs, was equal to its rate in French francs divided by 4.9249 to which the rate in Belgian francs, divided by 9.6368 has been substituted.

In spite of this, and as a convenience for the staff, the price of international journeys is subdivided, and on some tickets the fare for the journey in home territory is shown separately from that, or those, of each foreign one.

4. **Insurance.** — A special class of tickets covering insurance against personal risks, and luggage insurance tickets are still to be mentioned.

In addition to the insurance Companies, who work in close association with the railway Companies, some of the latter assume the risks involved and issue special tickets to cover them. This is an important question because, in exchange for reduced fare concessions, the Companies generally stipulate on the ticket that they decline all liability in case of accident whatever the cause. In other cases they expressly limit their liability (1). The issue of an insurance ticket offsets this justifiable limitation.

These special insurance tickets obviously cover loss and damage caused by train accidents only. The *Great Western Ry.*'s tickets, which cost 2-d., actually constitute an insurance policy guaranteeing the holder £ 500 in case of death, £ 3 per week in case of total incapacity or 15 shillings per week for partial incapacity (fig. 422). A 6-d. insurance ticket covering a return journey in a passenger carriage ensures double these benefits. Most of these are Edmondson tickets with a semi-circular segment cut out of the top border.

The Paris *Nord-Sud Railway* issued tickets in a special envelope which itself constituted an insurance policy (fig. 415).

(1) The *Midland Ry.* limited it to £ 100 in the case of workmen's tickets.

(To be continued.)

[625. 252]

The new F. S. (Italian State Rys.) device for varying the brake gear ratio,

by R. MARIANI and M. FASOLI,
Engineers of the Italian State Railways, Mechanical Engineering Department.

(Rivista Tecnica delle Ferrovie Italiane.)

A description of an apparatus for varying the brake gear ratio, which has up to the present given very satisfactory results on both passenger and goods vehicles of the Italian State Railways.

The necessity for being able to vary, under given conditions, the brake gear ratio has resulted in various more or less practical solutions based on different working principles.

* * *

These different principles consist in causing the following factors to vary :

— either the maximum pressure which may be realised in the brake cylinder;

— or the number of brake cylinders in action;

— or the brake gear ratio.

This latter principle is the one which has, of late, received the most attention, because it tends to simplify as much as possible the pneumatic portion of the brake equipment.

Decisive evidence regarding this was given during international trials of the « Breda » brake, in the course of which, for the first time in international tests, the brake force prescribed for the load was obtained in an accurate manner by the use of an apparatus employed to vary the brake gear ratio.

With such an apparatus, however, as with others of the same type, the regularity of operation is subject to the following conditions :

— either the apparatus, with suitable degrees of play, allows practically equal piston strokes to be realised in the two positions, « Empty » and « Loaded », in which case the brake gear must be provided with a dual purpose regulator, i. e. one which prevents the piston from making a stroke shorter than a determined length, as otherwise a short piston movement would produce a braking force corresponding to the « Loaded » position, even whilst the apparatus is in the « Empty » position, with the undesirable effect of locking the wheels;

— or the apparatus provides for two distinctly different piston strokes in the two positions, « Empty » and « Loaded », in which case, in order that the times of filling and discharging the brake cylinder should remain the same in the two cases, it is necessary, for the two positions, proportionately to vary the inlet and outlet orifices of the brake cylinders.

When vehicles have to be provided at the same time with the two devices, « Empty-Loaded » and « Goods-Passenger » (which vehicles necessarily represent a very high percentage of all covered

vehicles in the stock), the inlet and outlet orifices of the brake cylinder must lend themselves to modification both for changing from « Empty » to « Loaded » and for changing from « Goods » to « Passenger », which will obviously give rise to excessive complications.

The conditions cited above led to a search for an integral solution of the problem, which was furnished by the device described hereafter.

Made up of strong and simple parts, the apparatus does offer, in fact, the essential characteristic of allowing equal piston strokes in the two positions « Empty » and « Loaded », but ensuring in the most positive manner, whatever the piston stroke, that in the « Empty » position there will be no untimely application of a strong brake force, corresponding to the « Loaded » position.

* * *

The arrangement is shewn, in figure 1, in the « off » position. The horizontal levers 1 and 2 are connected to each other by two pull rods B and C, but whilst these pulls rods are connected directly to lever No. 2, they act on lever No. 1 through the medium of two angle pieces, D and E.

The angle pieces are pivoted on the levers by means of the pivot pins P1 and P2, which allow them to turn when the pawl N is in a suitable position.

When the handle M fixed on the sole-bar of the vehicle is operated by hand, the pawl engages one or other of the two angle pieces and fixes it rigidly on the horizontal levers, whilst the other angle piece remains free to turn.

It is evident that if the pawl N interlocks with the angle piece E, the pull-rod B (lowest brake-force) is engaged, whilst the angle-piece D, being free to turn on the pivot pin P2, allows the pull-rod C sufficient freedom of movement to make it impossible for it to come into operation when not required. The same conditions apply when the pawl N engages the angle piece D.

The essential characteristic of this apparatus, therefore, is that the portion of the apparatus provided by one pull rod and the corresponding angle-piece is given the greatest possible freedom when not engaged by the pawl, so as to avoid placing it in action when not required.

In order that, in the various « off » positions which the horizontal levers 1 and 2 can take up, according to the wear of the brake blocks, no changes will be produced in the reciprocal positions of the angle-pieces D and E and the pawl N, the length of the pull-rods B and C and the shape of the angle-pieces D and E are

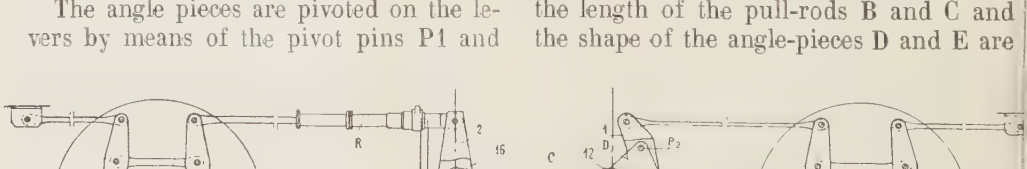


Fig. 1.

designed in such a way that, in the « Off » position, the two pull-rods B and C should be parallel, and that the fixed pin 10 and the pivot pins 11 and 12 which connect the pull rods to the angle pieces should have their centres in line, parallel to that through the points 14, 15 and 16 of lever No. 2.

comes into action, and so provides for a longer stroke just when the least increase is utilised.

Accordingly, the times necessary for filling and discharging the brake cylinders will also be fairly equal in the two cases, and will remain within the strict limits prescribed, without the inlet and

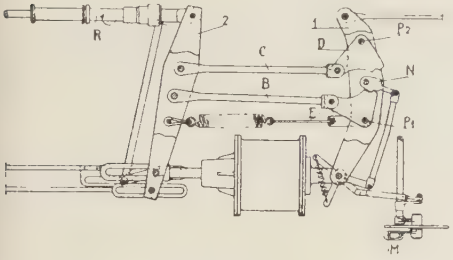


Fig. 2.

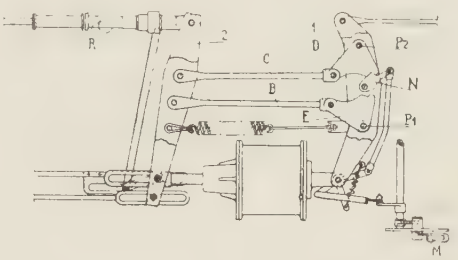


Fig. 3.

Figures 2 and 3, from which, for simplicity, the extremities of the brake rigging have been omitted, show the same apparatus under braking conditions for the two positions.

The control of the pawl N is arranged so that it can be operated even if the brake is under tension, i.e. applied, the pawl itself taking up the required position as soon as the brake is released.

As will be seen, the arrangement is extremely simple, made up of robust components, and is reliable in operation.

As regards the pneumatic operation of the brake, the apparatus described above is particularly suitable for satisfying in the greatest degree the conditions imposed by the international standards.

Actually, in spite of the two different gear ratios of the brake rigging, the piston strokes are obviously equal in the two cases, owing to the play g (fig. 1) which must be taken up before the pull-rod B

outlet orifices of the cylinders being modified.

Hence, on a vehicle provided with the « Empty-Loaded » device, it is possible at the same time to apply the « Goods-Passenger » apparatus, it being agreed that it is only for the latter alteration that the sizes of the orifices in question need be varied.

Further, whatever value may be decided upon for the play g, and whatever the piston stroke (consequently also in the case of poor adjustment of the brake gear) one of the two pull-rods B and C can never come in action untimely, as may happen on other types of apparatus, particularly if the piston stroke falls below a predetermined value.

The regulation of the piston stroke does not, therefore, require any special arrangements and can be modified by a single-way automatic regulator, that is, one whose action is confined to compensating the wear of the brake blocks.

The F. S. (Italian State) device for varying the brake gear ratio has been applied as much on goods trains as on passenger trains.

On *goods trains*, it was used for « *load-braking* » which, as is known, means increasing the brake force when a wagon load exceeds a certain amount.

In the case of *passenger* trains, it was used in conjunction with high-speed brakes.

In the latter case, the braking factor, which in one position is normal and represents therefore 75 to 80 % of the tare, is increased in the other position to 130 to 140 % of the tare, a high value which nevertheless does not cause skidding; the vehicles are at the same time provided with devices which ensure automatically a partial discharge of the brake cylinder, as the speed decreases.

Thus, two braking ratios can be applied on the same carriage, that which applies to normal coaches and that for vehicles provided with the high-speed brake, which allows a most flexible use of the stock, according to operating requirements.

[621.138.5 (.71) & 621.43 (.71)]

Methods used on the Canadian National Railways for maintenance of diesel engines, (*)

by I. I. SYLVESTER,
Special Engineer, Operation Department, Motive Power and Car Equipment Sections,
Canadian National Railways, Montreal, Canada.

(*Railway Mechanical Engineer.*)

The purpose of this paper is to present the results of experience gained in the maintenance of the three principal groups of railcar engines of from 200 to 350 H.P. comprising 26 units which have run over ten million miles in passenger service. These engines were placed in service on the Canadian National in 1925, 1927, and 1930, and even though they include improvements evolved over a five-year period, their maintenance problems are almost identical.

Soon after the commencement of diesel-electric railcar service, it was recognized that the oil-electric car offered great possibilities for economical operation and high availability, provided a satisfactory program for maintenance could be worked out. The lack of experience and knowledge on the part of those called upon to handle the engines, and of the designer and builder, regarding operating conditions, was a serious handicap in the early days. The seniority system, commonly followed in railway organizations, sometimes mitigated against the selection of the most capable men. Also the locomotive-shop staff had not previously been called upon to perform the type of work required in maintaining the fine working clearances of the wearing parts. However, these conditions have been quite general on American railroads and are mentioned here only because they had such an influence on the amount and type of maintenance required.

The most desirable condition is found in large numbers of identical equipment, centrally located, as expert supervision can be provided and the staff soon becomes accustomed to the new routine. The other extreme is found in railcar service where the units are operated over an extremely wide territory, which interferes with efficient training and seriously affects availability of the equipment due to dead-heading to and from a centrally located repair point. This latter condition applies particularly on the Canadian National, and the maintenance methods which follow were developed to cope with this situation. All these problems have demanded as much attention as the technical difficulties — possibly more.

The engines to which this paper applies in particular are four-cycle direct-injection engines of both British and American manufacture, the original research work having been carried out by the Wm. Beardmore Company at Glasgow prior to 1924, and the later development by the Westinghouse Company at their South Philadelphia plant. The crankcases of these engines are of cellular type, arranged for separate cylinder liners and made of cast steel. The crankshafts are supported in main bearings between each cylinder. Collar studs

(*) Abstracted from the paper « Maintenance of High-Speed Diesel Engines on the Canadian National Railways », which was presented at the semi-annual meeting of The American Society of Mechanical Engineers held at Detroit, Mich., May 17 to 21, 1937, and published in the May, 1937, issue of the *A. S. M. E. Transactions.*

hold the individual cylinder heads and liners to the crankcase, the main bearings being attached to the crankcase in a similar manner. The crankshafts are of carbon, nickel, and chrome-nickel steel forgings machined all over and drilled for pressure lubrication from the main journals to the crankpins. Cast-aluminium cylinder heads with steel valve seats to accommodate dual inlet and exhaust valves are also used on all these engines. Each head carries its rocker-arm mechanism and a single atomizer which is located at the center of the head where it is easily removed. Aluminium pistons, hollow floating wrist pins, and forged-steel connecting rods are also features of these engines. The development of crank end bearings for the connecting rods has been of considerable interest and will be dealt with later.

The cast-steel crankcase and underbed of thin section, together with rather extensive use of aluminum for such parts as pistons, cylinder heads, and gear cases have resulted in weights between 16 and 24.2 lb. per B.H.P. for these engines, which is in the lightweight class for rail service. The essential particulars of these units, which were the subject upon which maintenance investigations were carried out between 1925 and the present time, are given in table I. These include two columns of figures showing the maximum and minimum sizes, weights, and conditions. The tabulation of the extremes in table I indicates the design limits of the principal rotating and reciprocating parts around which most of the maintenance problems have centered.

The first feature of our maintenance consists of daily reports made out to show the fuel, lubricating oil, and other supplies used, mileage operated and load hauled, together with any trouble experienced during operation, and finally the repairs and inspection which are made daily. These data are compiled monthly to show the average condition obtaining for each car and, as all the equipment is included in this report, it permits the individual maintainer to compare his performance with that of others. This report also shows any troubles which occur with such frequency as to warrant investigation, thus keeping problems in order of their importance before the supervising staff. An analysis of these records over extended periods of operation also indicates any inherent weakness which can be remedied in new designs.

TABLE I. — **Principal proportions of the diesel engines.**

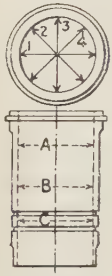
	Minimum.	*Maximum.*
Cylinder bore, in.	8	9
Stroke, in.	12	12
Brake mean effective pressure, lb. per sq. in.	77	82.5
Maximum cylinder pressure, lb. per sq. in.	750	800
Diameter of main bearing, in.	5.00	5.00
Length of main bearing, in.	3.70	4.65
Diameter of crankpins, in.	4.75	5.00
Effective length of crankpins, in.	2.29	4.04
Ratio of shaft diameter to cylinder bore	0.555	0.575
Ratio of wrist-pin diameter to cylinder bore	0.315	0.322
Ratio of piston length to cylinder bore.	1.4	1.9
Ratio of connecting-rod length to cylinder bore	2.43	2.21
Total weight of connecting rod, lb.	37.94	70.19
Weight of crank end of connecting rod, lb.	26.38	54.09
Weight of wrist-pin end of connecting rod, lb.	11.56	16.11
Weight of piston, lb.	18.19	35.00
Number of pressure rings	4	6
Number of scraper rings	1	3

In a general way the practices developed are a combination of railway maintenance ideas and those used in the repair of gasoline engines. Many of the methods employed are quite in line with those generally accepted in fleet operation of trucks and busses. In fact,

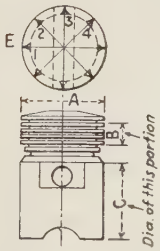
CANADIAN NATIONAL RAILWAYS
OIL ELECTRIC CARS
RECORD OF PISTONS AND LINERS

Car No. . . . . *15829.*
Eng. type . . . *Beardmore-six.*
Eng. No. . . . . *115.*
Date . . . . . *July 30, 1928.*
Miles . . . . . *82 877.*

		Liners.				Pistons.				Piston clearance.	
		1	2	3	4	1	2	3	4	D	E
1	A	8.280	8.281	8.281	8.281	8.215	8.216	8.218	8.217	0.063	0.065
	B	8.251	8.254	8.251	8.254	8.221	8.220	8.228	8.225	0.023	0.030
	C	8.254	8.250	8.247	8.250	8.232	8.235	8.235	8.234	0.012	0.022
2	A	8.256	8.258	8.255	8.256	8.213	8.212	8.219	8.214	0.036	0.043
	B	8.255	8.253	8.254	8.256	8.219	8.220	8.225	8.222	0.029	0.036
	C	8.253	8.251	8.252	8.254	8.232	8.235	8.238	8.235	0.014	0.021
3	A	8.284	8.285	8.282	8.282	8.215	8.212	8.219	8.214	0.063	0.069
	B	8.256	8.252	8.259	8.257	8.221	8.223	8.229	8.223	0.030	0.035
	C	8.253	8.253	8.251	8.253	8.231	8.235	8.241	8.233	0.010	0.022
4	A	8.275	8.275	8.268	8.273	8.209	8.214	8.217	8.214	0.051	0.066
	B	8.257	8.257	8.252	8.253	8.219	8.224	8.226	8.223	0.026	0.038
	C	8.254	8.254	8.248	8.250	8.230	8.235	8.240	8.235	0.008	0.024
5	A	8.270	8.272	8.271	8.269	8.215	8.218	8.217	8.212	0.054	0.055
	B	8.254	8.254	8.252	8.253	8.223	8.225	8.226	8.223	0.026	0.031
	C	8.253	8.253	8.247	8.250	8.235	8.235	8.237	8.236	0.010	0.018
6	A	8.271	8.269	8.268	8.268	8.216	8.218	8.219	8.216	0.050	0.055
	B	8.253	8.253	8.255	8.256	8.222	8.223	8.225	8.222	0.030	0.031
	C	8.250	8.250	8.253	8.254	8.231	8.235	8.236	8.232	0.017	0.019
7	A										
	B										
	C										
8	A										
	B										
	C										



Liner



Piston

REMARKS.

Ring grooves badly worn on all pistons, especially on the exhaust side. Land broken between No. 1, No. 2 and No. 3 ring grooves on No. 1 piston.

Recorded at . . . *Edmonton.*
Recorded by . . . *I.I.S.*

CANADIAN NATIONAL RAILWAYS
OFFICE OF CHIEF ELEC. ENGR.
MONTREAL, QUE., DEC., 10, 1930.

Fig. 1. — Record of the rate of piston and cylinder-liner wear.

much inspiration has been drawn from this source when grappling with the more difficult problems. In these installations engine size and weight have been kept to a minimum with the result that provision for successive wear and remachining is not generally made to the same extent as in steam-locomotive work. One principal difference lies in the rather extensive use of welding and, of late, chromium plating as a means for reconditioning wearing parts. Fusion welding, as developed in steam-locomotive service, is now being used extensively in diesel-engine repairs and much progress has been made in recent years in the use of the electric arc and acetylene flame for the building up of worn parts as well as repairing fractures. Good results were not obtained in this new application without overcoming several technical difficulties because the original development on the railway had to do with structural-steel plates and boiler work in which the metal was quite readily welded. However, in the repair end, large varieties of special metals had to be dealt with and in many instances heat-treatment to regain physical properties of the finished part became a problem.

Considerable ingenuity has been required to develop successful welds on such parts as pistons, cylinder liners, and valve gear. The service engineers of companies which supply welding materials have been of great assistance in the development of suitable welding rods for this work and in providing instructions for their satisfactory use. This process is now responsible for reduction in our maintenance costs and some descriptions of unusual repairs by this method are given under various headings which follow.

Within the last year or so we have been investigating the merits of hard chromium plating in an effort to lower the rate of wear on certain parts and also as a means of regaining the original size where possible. Worn surfaces on pins and journals of crankshafts, wrist pins, cylinders, and various other small parts have been built up with chromium and satisfactorily salvaged. This type of plating must not be confused with the decorative plating which is used more or less in the form of a lacquer to preserve the copper-nickel plating underneath, as it is applied directly to the base metal. We are using thicknesses varying from 0.003 to 0.015 in., depending on service conditions. Excessively thick plates are not found desirable and, for that reason, the original sizes are not always regained.

Cylinders.

The cylinders in these engines are in the form of relatively thin tubing, accurately machined all over, and are snugly fitted in the crankcase. They are of the wet type, being surrounded by cooling water, and the joint at the bottom is made by means of rubber rings.

Our lack of information regarding the rate of wear on cylinders and pistons of railcar engines, some ten years ago, resulted in the introduction of a system of recording the sizes whenever these parts were dismantled. A copy of the form which has been used for recording this information is shown in figure 1. At first it was felt that these records would give us an indication of the direction of wear around the circumference of the cylinder and possibly lead to correction of it. However, there was found to be no regularity in this regard, some 60 % showing maximum wear at right angles to the crankshaft and the remainder lengthwise or at some intermediate angle. We have been unable, even by painstaking study of a great number of measurements, to associate this feature with any other detail of engine construction or performance. The principal value of this form has been in the determination of average rate of

wear on cylinders of different groups of engines, thereby providing a basis for the maintenance program. The comparison of wear resulting from the use of different fuels and of different cylinder materials has also been gained from these records, and they have also shown the accuracy with which replacement cylinders are installed.

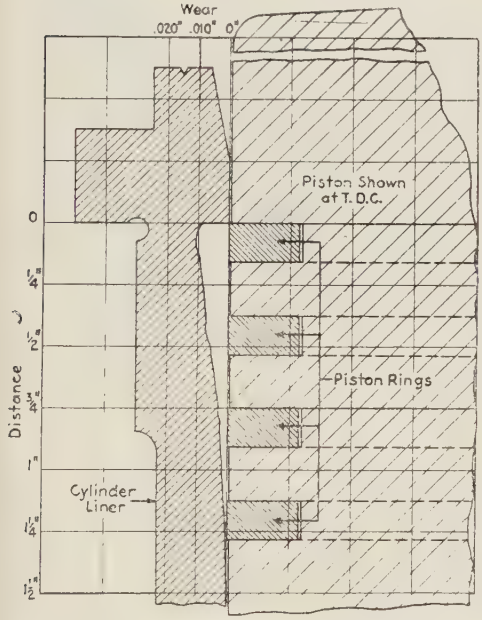


Fig. 2. — Location of maximum wear on a cylinder liner. — Illustration exaggerated to show details of the worn portion.

A typical example of the location of maximum wear is shown in figure 2. This illustration is exaggerated to show the details of the worn portion. Although the wear is always greatest at top dead center, it is rather unusual for it to be almost entirely confined to such a short distance from top-ring travel. The wear ad mid-stroke is always negligible and is only perceptible at bottom dead center on these engines.

What can be accomplished in reconditioning cylinders for further operation is, in the main, controlled by the number of engines involved. Several factors, however, must be given careful consideration, and too much emphasis cannot be placed on the value of accurate measurements of the wear occurring on both the pistons and cylinders. The analysis of these data permits important decisions to be made, such as whether reconditioning will be necessary and economical on both of these parts or if this attention can be confined principally to the cylinders. Where piston wear is relatively low, it is most economical to regain the original cylinder size by applying a bushing to existing cylinders as in locomotive service, thus avoiding any necessity for work on the pistons or supplying off-size rings.

Figure 3, which was drawn from an inspection of a large number of forms such as shown in figure 1, shows the average rate of wear on the three groups of engines which we have in passenger service. An analysis of cylinder wear on individual engines produces a curve showing a gradual increase in wear up to 45 000 to 55 000 miles and then the wear is accelerated considerably. The

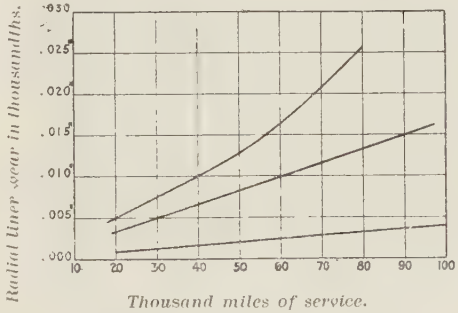


Fig. 3. — Average rate of cylinder wear in railcar engines.

shape of the top curve is more in line with the usual individual engine investigations. However, in plotting several hundred measurements, it is impossible to establish anything but a straight line as being the average rate of wear which

can be expected. These curves are all the result of wear at top dead center on mild-steel cylinders which are fitted with aluminum pistons.

There are over 150 cylinders of similar type and size in service, which has permitted the establishment of sizes both above and below those which were set up by the manufacturers. It has been found that 1/16-in. wear on the diameter can be economically tolerated, giving due consideration to the increase in lubricating-oil consumption which results from wear on this part. In reconditioning, however, steps of 0.025 in. are desirable and economical in the reclaiming methods described later. It requires about 0.075 in. oversize to clean up properly a cylinder worn 1/16 in. because of the wear being quite eccentric, or otherwise irregular, relative to the center line of the cylinder. In establishing these sizes it has been necessary, of course, to consider them in relation to similar steps on the pistons and the stocking of seven sizes of piston rings to suit. In the beginning, existing cylinders were bored out and oversize pistons applied. Later, as a result of an accumulation of worn standard-size pistons, undersizes down to 0.075 in. below standard were established. The symbols for size identification, which are stamped on both pistons and cylinders, are shown in table II.

TABLE II. — **Sizes and letter designations for pistons and cylinders.**

Symbol.	Size.	Symbol.	Size.
A	0.075 in. oversize	*E*	0.025 in. undersize
B	0.050 in. oversize	*F*	0.050 in. undersize
C	0.025 in. oversize	*G*	0.075 in. undersize
D	Standard size.		

The arrangement does not require the previous size of the piston to be removed, but merely the addition of the new size. On cylinders, the sizes are stamped on the outside diameter of the collar which extends above the crankcase where it can be observed without removal of the head on most of the engines. The curvature of this surface permits easy removal of the previous size symbol when the cylinder is being rebored.

We are also reconditioning cylinders by depositing a band of metal on the worn portion for about 3 in. down from top dead-center position, with the electric arc. The cylinder is cleaned by grinding with a hand grinder to remove the surface metal and it is revolved during the welding process to keep distortion to a minimum. No attempt is made to regain the cylinder size by this method, but they are bored out about 0.015 in. above the original size and ground to 0.025 in. oversize. This means that a cylinder might be worn 1/16 in., but be returned to service only 0.025 in. larger than previously. A section through the upper part of a cylinder which has been reconditioned in this manner is shown in figure 4. This enlarged section shows the typical porosity of the electric weld. The deposited metal, however, is considerably harder and more wear-resistant than the original cylinder material. The pores possibly are an advantage in regard to the retention of lubricant on this zone where the high temperatures often interfere with proper lubrication.

Figure 4 also shows a cylinder liner from one of the six-cylinder engines which was chromium plated at the worn portion for about 4 in. down from the top-ring travel. This was taken while the cylinder was being reground after plating. It had been worn about 0.024 in. on the diameter and was plated sufficiently to bring it back to standard size and about 0.010 in. to clean it up. The vertical marks from the original use of this cylinder and the ring formed at bottom dead center are noticeable. A witness mark of the groove caused by maximum wear at the top is just in evidence and was removed during the fi-

nish-grinding. It is possible to set up these cylinders by the original surface and the measurements indicate that the cylinder is within 0.002 in. of the original size. The results of this application are not yet available. However, it

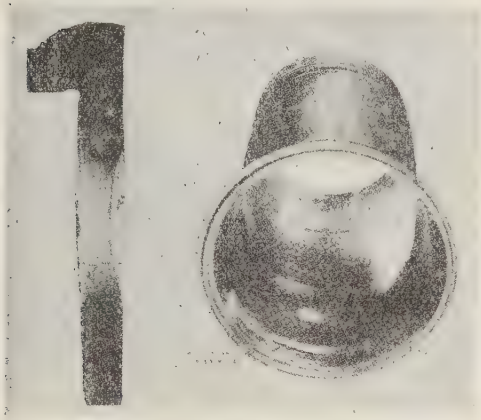


Fig. 4. — Left : Worn portion of a cylinder repaired by electric welding. — Right : Cylinder liner chrome plated for about 4 in. down from the top-ring travel.

will be watched with particular interest, inasmuch as it has to contend with elevated temperatures as well as abrasion. The fact that chromium is particularly resistant to chemical action of the fuel oil may also provide some data in connection with the « corrosion theory » which is being discussed so extensively.

In addition to harder wearing surfaces resulting from the various reconditioning methods which have been used on mild- and tempered-steel cylinders, some very interesting information pertaining to the use of cast iron and nitrided steel for this purpose has been developed on these engines.

In the application of cast iron in place of steel, it has been necessary to reduce the cylinder size somewhat in order to provide sufficient strength, and this may have had an influence on the results. We have been unable to find a great difference in rate of wear on nickel iron, ordinary grey iron, or iron cast centrifugally. Any of them, however, appear to wear only about half as rapidly as mild steel. The greatest difficulty with the use of this metal on these particular engines, which were designed for steel cylinders, is in the application within the narrow confines of the crankcase.

Cylinders of nitralloy steel are giving a very creditable performance. Tests have been carried out over 259 000 miles in obtaining comparisons. These indicate that the maximum wear is 0.007 in. in 80 000 miles, which is only about one-fourth to one-fifth the amount on mild steel in similar service. The attempts which have been made to reclaim any cylinders of this material are unprofitable because of the difficulty in grinding the excessively hard surface. Also the second wear is inferior because the surface hardness is removed.

The pitting of the steel cylinders, as a results of the action of the cooling water on the outside, is also a problem which has been dealt with in maintenance. Zinc and aluminum spraying of

Fig. 5. — Left : Piston which had the ring belt machined off, acetylene welded, heat-treated and machined. — Right : The piston before machining.

some of the cylinders has been used to prevent this action in order to continue the cylinders in service for a longer period. A certain amount of pitting oc-

curs at all times, but usually the cylinder is worn to the limits mentioned before serious weakness results. A limit of 5/32 in. wall thickness, measured at the bottom of the deepest pit, has been set up for steel cylinders in order to avoid this condition. All liners are coated with a corrosion-resisting paint during manufacture or reconditioning to counteract the attack of the cooling water. No trouble whatever has been experienced with pitting on cast-iron or nitrated cylinders.

Pistons.

Of the various wearing parts of these engines, the pistons present the most complex problem, and have been the subject of considerable study both as to design and maintenance. The almost continuous variation in speed and load over wide ranges, which has to be dealt with in railway traction, makes greater demands on the piston than most services. Further, the introduction of aluminum-alloy pistons so essential to these high-speed, light-weight engines, has tended toward higher lubricating-oil consumption—first, because of the varying clearances between the piston and cylinder resulting from the previously mentioned service requirements; and, second, because the comparatively soft aluminum alloy wears more rapidly than other piston materials.

Considerable painstaking work and time have been necessary in developing maintenance methods to meet these conditions. However, a very satisfactory reduction in lubricating-oil consumption and reconditioning these parts has followed our efforts and we have been enjoying the benefits for several years.

Of the sand-cast, die-cast and forged-aluminum pistons which have been employed since 1925, the forged metal is most suitable, as it is stronger, more ductile and wear-resistant. It is more expensive, however, because of the more costly process of manufacturing the metal and machining this part from the solid forging.

Wear of the ring grooves in any of the alloy pistons appeared as a difficulty early in the operation of these engines. It was, in fact, this item which determined their useful life. In bringing this factor within reasonable limits, it has been necessary to consider the effect of the fuel oil as well as the design and metal from which the pistons are manufactured. In the early days, fuel specifications were written in broad terms to take care of the very wide territory in which these engines operated. However, it seems that two fuels can have apparently identical physical characteristics and yet the reaction on the piston from a wear standpoint may be widely different. Improved fuel specifications, which have been developed, and the adoption of narrower and diametrically thicker rings proved helpful. However, there was still the necessity for reconditioning the ring grooves. Wear on the top grooves has been limited to 0.006 in. and when this is exceeded the grooves are machined out to take overwidth rings. It has been proved that good piston rings in equally good grooves are steps in the right direction, and much of our effort has been directed toward this end.

Engines such as these, designed with minimum weight, of necessity have the wrist-pin hole somewhat above the center of the piston, which has a very limiting effect on the width of the lands between the piston rings. This restriction does not allow for much widening of the groove until the land is altogether too weak and subject to breakage. We have, therefore, limited this feature of our reclaiming operations to 0.025 in. over standard width. The rate of wear on the ring lands remained so much greater than that occurring on the rubbing surfaces of the piston or wrist-pin hole that there are many pistons which could be used further provided the ori-

Fig. 6. — Enlarged section of a piston before being acetylene welded

ginal condition could be regained at the ring belt. To accomplish this, acetylene welding is being employed and, in figure 5, at the right, is shown a piston which has had the entire ring belt machined off and new metal deposited by this method. At the left appears a similar piston after heat-treatment and machining. In the investigation prior to the adoption of this method, sand-cast and die-cast pistons were examined both before and after welding, and some of the results are shown in figure 6. This shows an enlarged section of an unwelded piston located in this work. This particular one is somewhat worse than average regarding porosity. Figure 7 shows a section illustrating a welded piston, for comparison; this enlargement shows the condition of the welded ring belt after machining. It will be noted that the porosity even in the newly deposited lands is not nearly as serious as in the original casting shown in figure 6. The strength of original and welded lands on pistons was determined by the load required to break them off one at a time. Typical loads required to break lands off an original piston are 35 000, 36 000, and 35 500 lb. while typical loads for a welded piston are 60 000, 66 000 and 64 000 lb.

The machining of the outside diameter of the pistons has been treated in line with that described for the cylinders. The welded pistons are always machined down 0.025 in. in diameter which removes any distortion caused during the welding process. The wrist-pin holes were found to close in slightly under this treatment and this is an advantage, since it permits the wrist pin to be refitted to standard clearances.

In connection with newly manufactured pistons of 8 to 12 in. diameter, it has been demonstrated repeatedly that a certain amount of distortion takes place soon after they are placed in service, and, in connection with recondi-

Fig. 7. — Enlarged section of a piston after being acetylene welded.

CANADIAN NATIONAL RAILWAYS
Oil electric cars
Record of engine shaft measurements.

Car No. . . . . *15829.*
Eng. type . . . *Beardmore-six.*
Eng. No. . . . . *113.*
Date . . . . . *January 20, 1931.*
Miles . . . . . *199 548.*

		Diameter of journals.		Difference.		Diameter of crank pins.		Difference.	
		F	R	V-H	F-R	F	R	V-H	F-R
1	V	4.9960	4.9940		0.0020	4.7280	4.7300		0.0020
	H	4.9980	4.9965		0.0015	4.7280	4.7300		0.0020
2	V	4.9960	4.9960		0	4.7290	4.7320		0.0030
	H	4.9950	4.9955		0.0005	4.7300	4.7315		0.0015
3	V	4.9950	4.9950		0	4.7270	4.7310		0.0040
	H	4.9955	4.9955		0	4.7275	4.7320		0.0045
4	V	4.9940	4.9925		0.0015	4.7325	4.7245		0.0020
	H	4.9935	4.9935		0	4.7335	4.7355		0.0020
5	V	4.9940	4.9945		0.0005	4.7290	4.7320		0.0030
	H	4.9950	4.9960		0.0005	4.7305	4.7315		0.0010
6	V	4.9960	4.9970		0.0005	4.7315	4.7325		0.0010
	H	4.9960	4.9965		0.0005	4.7325	4.7335		0.0010
7	V	4.9950	4.9960		0.0010				
	H	4.9965	4.9975		0.0010				
8	V	4.9950	4.9955		0.0010				
	H	4.9965	4.9970		0.0010				
9	V								
	H								

Notes.

F = Front nearest to gear case.

R = Rear.

V = In vertical plane.

H = In horizontal plane.

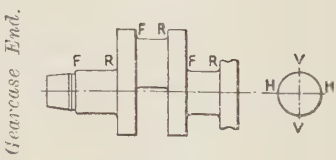
Difference between V an H indicates ovality and should be zero.

Difference between F and R indicates wear and should not exceed 0.002 in.

When being measured the crankpin to be on top dead center.

If serious ovality is found on main journals, the measurements shall be recorded in relation to a top dead center.

Recorded at. . . *Winnipeg, Man.*
Recorded by. . . *Geo. F. Shaw.*



CANADIAN NATIONAL RAILWAYS
OFFICE OF CHIEF ELEC. ENGR.
MONTREAL, January 30, 1931

Fig. 8. — Form for recording rate of crankshaft wear.

tioned parts, this does not seem to be noticeable. In the ordinary course of events, pistons which have been reconditioned after 75 000 miles have been fitted with smaller clearances without any evidence of seizure.

Diesel-engine crankshafts are handled in a manner similar to the pistons and liners in regard to records of wear and sizes. In figure 8 is shown a copy of this form which is typical of the wear occurring on this part. In some studies made several years ago comparisons were made between nickel, chrome-nickel, and carbon steels for wear resistance, and it was found that there was very little choice between them. However, in replacement, the trend has been toward alloy steels because of the harder bearing surfaces and greater strength. On main journals, the wear varies between one and two thousandths on the diameter in 100 000 miles and the crankpins show six to nine thousandths during this period on the usual run of crankshaft steel.

The nitralloy crankshafts which were applied several years ago are standing up remarkably well, and, on the average, indicate the wear to be about one-sixth that usually found. In practically every instance, regardless of the type of steel, however, the crankpin wear is four to five times that found on the main journals. In reconditioning crankshafts the practice is to turn the crankpin and journal which is in the worst condition first, and then use the size which has been thus established for the remaining pins and journals. In this way it is not found necessary to establish definite undersizes for this part, and in a measure this has extended the life of the shafts, as only sufficient metal is removed to true them up.

Very good results have been obtained with a Webber tool in turning crankpins. This tool is one of the type which is used in the lathe and follows the crankpin around in its normal path when revolving on the main journal centers. Any pins which are oval are first filed to make them round so that the tool will be guided by a fairly true surface throughout the entire operation. Wooden polishing blocks are employed and fine abrasive compounds are used in the final finishing, producing accuracy in line with manufacturers' required tolerances.

Connecting-rod crank-bearings.

One of the problems which developed in the early use of these engines, and for which the maintenance staff was obliged to find a solution, related to crank-bearing failures. This amounted to cracking of the babbitt lining in the rod or top half of the bearing which continued until most of the babbitt in the high-pressure area was loose and broken in small pieces. If this condition was not detected, the detached pieces pounded out until they interfered with lubrication, causing heating, or the bearing shell came down on the crankpin. It was found that it did not take long for most of the babbitt to become loose after the initial crack had formed and it was not unusual for loose babbitt to go unnoticed until the bearing was removed for inspection. The loose pieces would, of course, fall out when the bearing was disturbed, and renewal was necessary. Cracking never occurred in the bottom half of the bearing and the main bearings also were practically trouble free. The fact that the babbitt metal employed included all the popular tin-base alloys and from failures which occurred with several of these which were applied under expert supervision, there was a strong belief that the loads were too high. To offset this, however, a study of the records indicated that some bearings operated in excess of 200 000 miles without renewal. These, of course, were rather exceptional in the early days. However, these rare occur-

rences indicated the direction of improvement, and final solution of the problem followed.

Flexing of the bottom end of the connecting rods was given attention and, in later installations, bearing sizes were increased and the rods strengthened. However, the trouble continued and, at one stage of the investigation, several methods of babbitting the crank bearings were tried. These included babbitting direct on the steel rods without the use of shells, and the use of bronze-lead combinations which were only partially successful. The experience which was gained resulted in some very definite ideas regarding the best type of crank bearing for railway traction.

Protection of the crankshaft against damage under severe and abusive conditions is an important factor because passenger trains must be on time if humanly possible. This means that under abnormal conditions an engine may be operated without a proper supply of lubricating oil, with disastrous results. The development of a crank-bearing shell which can be operated after the babbitt has disappeared without damaging the shaft is the answer. The use of a shell of this type which can be easily removed for inspection or replacement, has permitted reasonable maintenance and provided good protection for the crankshaft.

As a consequence of the poor results obtained with the bearings in the early days and the time required to obtain replacements and deliver them to remote parts of the railway system, attempts were made to manufacture bearings in the railway shops. At first these were not very successful, but by the use of special babbitt with high lead content, together with improved practice regarding its application, the crank bearings have ceased to be a troublesome feature in maintenance. Lead is usually thought of as an extremely soft and ductile metal. However, the addition of antimony and arsenic gives it a surprising hardness without interfering with its antifriction qualities.

Bronze shells with a phosphorus content were also found to be unsuitable and the best results are being obtained with babbitt, and shells of the composition given in table III. The jig which is employed is made solid in order to retain the heat and it is kept between temperatures of 250 and 300° F. The tinning bath is composed of babbitt containing 70 % tin and 30 % lead solder, maintained between temperatures of 600 and 650° F. Considerable care is exercised in maintaining the babbitt pot at 1 050° F., and the molten metal is poured from a ladle previously raised to the same temperature. This ladle is of a large size enabling a complete pour to be made in one operation. The shell is not removed from the jig until it has cooled to 225° F.

TABLE III. — **Analysis of bearing material.**

Element	Babbitt, per cent.	Lead-bronze, per cent.
Copper	1.00	77
Lead	78.75	15
Tin	1.25	8
Antimony	18.00	....
Arsenic	1.00	....

During the tinning process the shell is completely immersed in the bath and left until it has reached a uniform temperature, being removed to coat it with soldering flux. This, briefly, is the practice employed during the process and great care is exercised to insure cleanliness and accuracy.

The rough hammer-and-chisel maintenance methods credited to the railway organization no doubt caused unnecessary failures, but this same method applied to the babbitt of the big-end bearing resulted in a test definitely proving the degree of adherence between the babbitt and shell. When this chipping test showed that there was no tendency for the babbitt to peel away from the

shell, an almost perfect bond existed between the two metals. The feature since that time has been only the reproduction of the conditions under which this satisfactory bonding occurred, and in this respect the human element plays an important part. There is now only an occasional bearing which shows trouble on inspection, and the average life of these is well above 100 000 miles. Most of the engines go from shopping to shopping without renewal.

In the manufacture of bearings, certain slight changes were found beneficial. These are illustrated in figure 9 and show the details of a bearing which was one of the worst offenders, together with particulars of the working conditions. Figure 9 shows the original design and the improvement which has been in successful operation for several years. Anchor grooves and oil grooves were eliminated and the babbitt thickness has been materially reduced. Oil pockets were cut at right angles to the rod center line and end collars have been added.

Bearings of 4 3/4 to 5 in. diameter are installed with only 0.001 to 0.002 in. clearance, and operate at normal temperatures with clearances of 0.003 in.

General.

A certain amount of distortion is found in the main-bearing openings of the crankcases after several years of service. However, the practice of line reaming the main bearings in place, which has been adopted, takes care of this. The slight differences in babbitt thickness which results from this practice is of no consequence. The same type of bearing is used in the mains as in the connecting rods previously described. Extremely long life is obtained from these. However, in the ordinary course of events they are renewed at each general overhaul when the crankshaft is reconditioned. In other words, these bearings do not wear out but are replaced with bearings of smaller size to accommodate the reconditioned shaft.

The reconditioning of aluminum cylinder heads with steel valve seats has

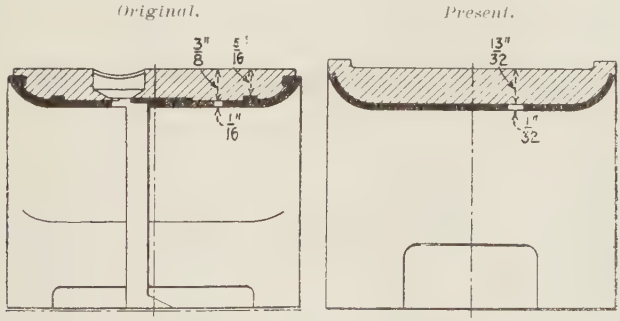


Fig. 9. — Changes in design of connecting-rod crank bearings which have increased the service life of the bearings. These bearings are for an engine with the following characteristics :

Diameter of crankpin, in.	4.75	Rubbing speed, ft. per sec.	16.5
Original effective length of crankpin, in.	2.043	Number of bolts in crank end of connecting rod	2
Original projected area of connecting-rod crank bearing, sq. in.	9.7	Capacity of lubricating-oil pump at 800 r.p.m., gall. per min.	34.1
Pressure, lb. per sq. in., gas load only	4 400	Number of cylinders	6
Pressure, lb. per sq. in. gas inertia	3 560	Engine speed, r.p.m.	800

presented no problems uncommon to automobile engines. Occasionally a head will become cracked, and excepting when this occurs in the combustion-pressure area, it is repaired by welding. A 50-lb. hydraulic test of the water space is made following such repairs. Reaming of the seats is required at periods of 100 000 miles. Exhaust-valve guides also require renewal at this period.

The four-cylinder engines have been practically free from any renewal of parts in the gear cases in spite of mileages around 500 000. On the six-cylinder engines, however, this unit becomes noisy at about 150 000 miles and will require renewal of gear-case parts at 200 000 miles. It is likely that the difference in torsional vibration is responsible for this, and on some occasions it has been noted that early trouble with the gears was associated with an improperly adjusted vibration damper.

The type of wrist pin with which these engines are fitted, which is free to revolve both in the piston and the bearing, is very easy to maintain. It is only in the last few years that they have required any attention. Wear of 0.006 in. is the maximum which has been found even after many years operation. This is rather surprising as the loads on this part are high. The wear on wrist-pin bosses in the piston and also in the rod bushing is relatively low, and the only measure which has been taken to regain the original clearances on worn parts is in providing 0.005 in. oversize pins by means of chromium plating.

Fuel-injection pumps and atomizers are sent in to a central repair shop which is adjacent to a toolroom equipped to make adequate repairs. Plungers and valves are reduced in diameter 0.003 and 0.005 in. as required, and new bushings are fitted. Considerable technique has been developed in this work, and lapping of the parts which at one time was a tedious job has been cut to a minimum. Each pump unit is given a static test of 5 000 lb. pressure as an initial check for leakage. The completed pump is put on an operating test and the fuel quantities balanced using the atomizers which are to be installed with it.

Governors, lubricating-oil pumps, water pumps, and primary fuel-oil pumps operate over 200 000 miles between shopping periods without trouble. Often these will go to the third general overhaul before requiring much attention. Two or three spare units of each type have been provided for protection and are handled similarly to pistons and liners, being repaired at a central shop and sent to outlying repair points as occasion demands.

Some further impressions of the average mileage which is being obtained from various engine parts under the maintenance practices which have been

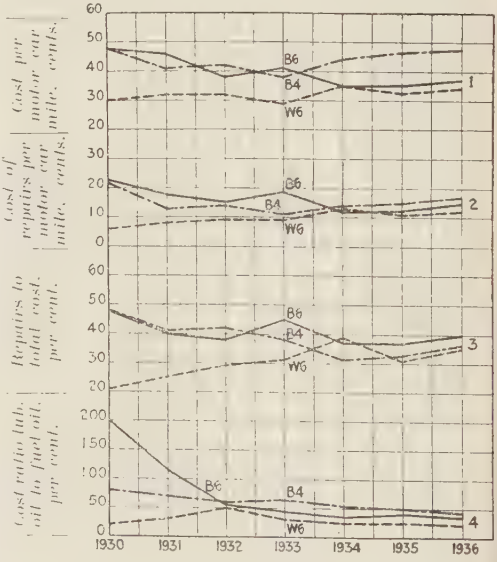


Fig. 10. — Cost per car mile for diesel-electric operation.

During the period shown in this figure the engines were operated an average of 192 miles per day. The letters on the curve refer to Beardmore four- and six-cylinder and Westinghouse six-cylinder engines.

TABLE IV. — **Maintenance practice of diesel-engine parts.**

Part.	*Limits of wear.*	*Average mileage.*	*Type of repairs.*
Crankshaft	0.006 in. out-of-round on two or more crankpins	250 000	Recondition.
Cylinders	Worn between 0.045 and 0.06 in. on diameter	150 000	Recondition.
Pistons	Worn 0.01 in. above top ring; 0.006 in. clearance in three ring grooves; 0.005 in. clearance in wrist-pin hole	100 000	Recondition.
Connecting-rod bearings	Clearance maintained between 0.003 in. and 0.004 in. by adjustment of shims	No record of worn out bearings.	
Wrist pins	Worn 0.006 in. on diameter	300 000	Renew.
Exhaust valves	Renew when bent, warped, or stem worn 0.005 in.	75 000 200 000	Grind. Renew.
Exhaust-valve guides	Renew when worn 0.008 in.	100 000	Renew.
Piston rings	Gap opening increased to 1/8 in.	75 000	Renew.

described are shown in table IV. This also shows data relating to the limits of wear which are in effect.

Further details of the more important factors pertaining to the cost of maintenance are included in figure 10 for years 1930-1936. The average trend of total cost per mile, shown in curve 1, has been downward to 1934 and has held between 36 and 40 cents per mile since then. One of the greatest influences on total cost is total miles and, unfortunately, as a result of recent alterations in train schedules, the runs which have been operated by this equipment are shorter than previously. At one time groups of these cars were on runs of 300 miles per day and this dropped to 220 miles in 1929 and has made a further drop of 13 per cent since. The fact that repair cost has held constant, or been slightly lowered, as shown in curve 2, in spite of this, is very gratifying. It has been impossible to obtain the cost of engine repairs separate from the other mechanical and electrical repairs. However, the fact that there has been a general improvement in this is seen from curve 3, which gives the repairs in per cent of total cost. Last, but not least, in curve 4 is shown the very satisfactory reduction in lubricating-oil consumption which has resulted from a systematic handling of pistons and cylinder-liner repairs.

Some ideas on depreciation of diesel-engine equipment can be gained from our experience. In the first place the results after 12 years with the oldest engines indicate that an estimated life of 20 years is conservative. The possibility of engines of this type becoming obsolete or the costs rising to where they are uneconomical after extended service is remote. By inexpensive investigation, it is possible during overhaul to improve and modernize the engines, even within the narrow confines of existing crankcases, with beneficial results. Finally, by careful records of wear being kept, a systematic handling of repairs can be set up which results in a lowering and stabilizing of engine-repair costs. Up to the present it would appear that depreciation is practically taken care of by renewal of the active parts.

[621. 132.5 (.73)]

Kansas City Southern 2-10-4 freight locomotives.

(Railway Mechanical Engineer).

Fig. 1. — One of the oil-burning 2-10-4 type locomotives built by the Lima Locomotive Works for the Kansas City Southern.

The Kansas City Southern received ten freight locomotives of the 2-10-4 type from the Lima Locomotive Works during the latter part of the 1937 summer, five of which were equipped for burning oil and five for burning coal. Neither in point of total weight, weight on drivers, nor combined heating surface are these locomotives the largest which have been built. The cylinder tractive force of 93 300 lb., however, has not been exceeded, and their boiler pressure of 310 lb. is the largest which has yet been employed in locomotives of this type with staybolt type fireboxes. The principal dimensions of these locomotives are compared in the accompanying table with the two largest locomotives of this type.

The boiler.

The boilers on these locomotives are 92 in. outside diameter at the first course; the second course is tapered, and the third course, which is straight, has an outside diameter of 102 in. The

The Kansas City Southern locomotive compared with the two largest locomotives of the 2-10-4 type.

Road	Chesapeake & Ohio	Atchison, Topeka & Santa Fe	Kansas City Southern
Road No.	3002	5000	900
Builder	Lima	Baldwin	Lima
Date built	1930	1931	1937
Tractive force, eng., lb.	91 584	93 000	93 300
Tractive force, booster, lb.	15 000	—	—
Weight engine, lb.	566 000	502 600	514 000
Weight on drivers, lb.	373 000	348 200	353 000
Cylinders, diam. and stroke, in.	29 × 34	30 × 34	27 × 34
Driving wheels, diam., in.	69	69	70
Steam pressure, lb.	260	300	310
Grate area, sq. ft.	121.7	121.5	107
Heating surface, firebox, sq. ft.	645	592	500
Heating surface, total evap., sq. ft.	6 635	6 143	5 154
Superheat. surface, sq. ft.	3 030	2 550	2 075
Comb. evap. and superheat., sq. ft.	9 665	8 693	7 229

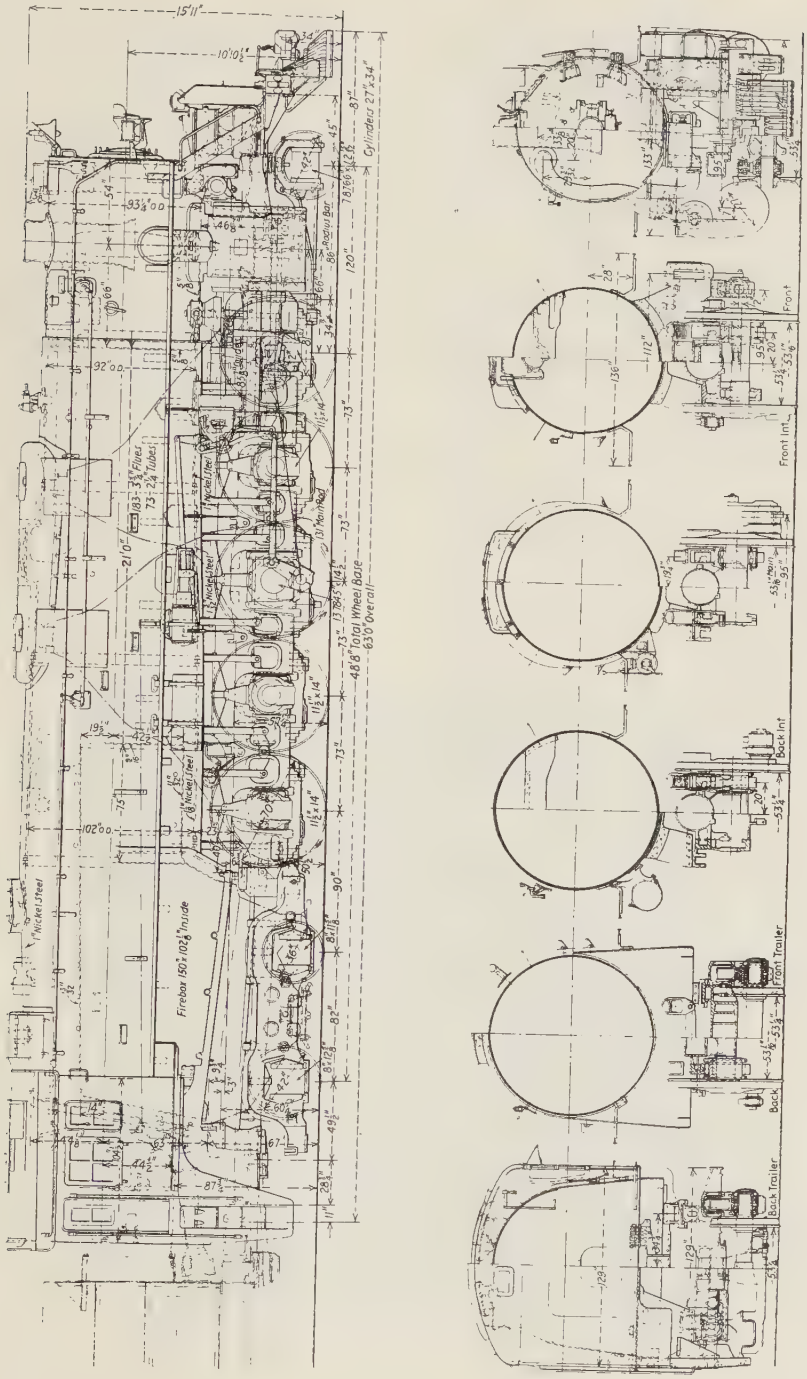


Fig. 2. — Elevation and cross-sections of the Kansas City Southern 2-10-4 type locomotive.

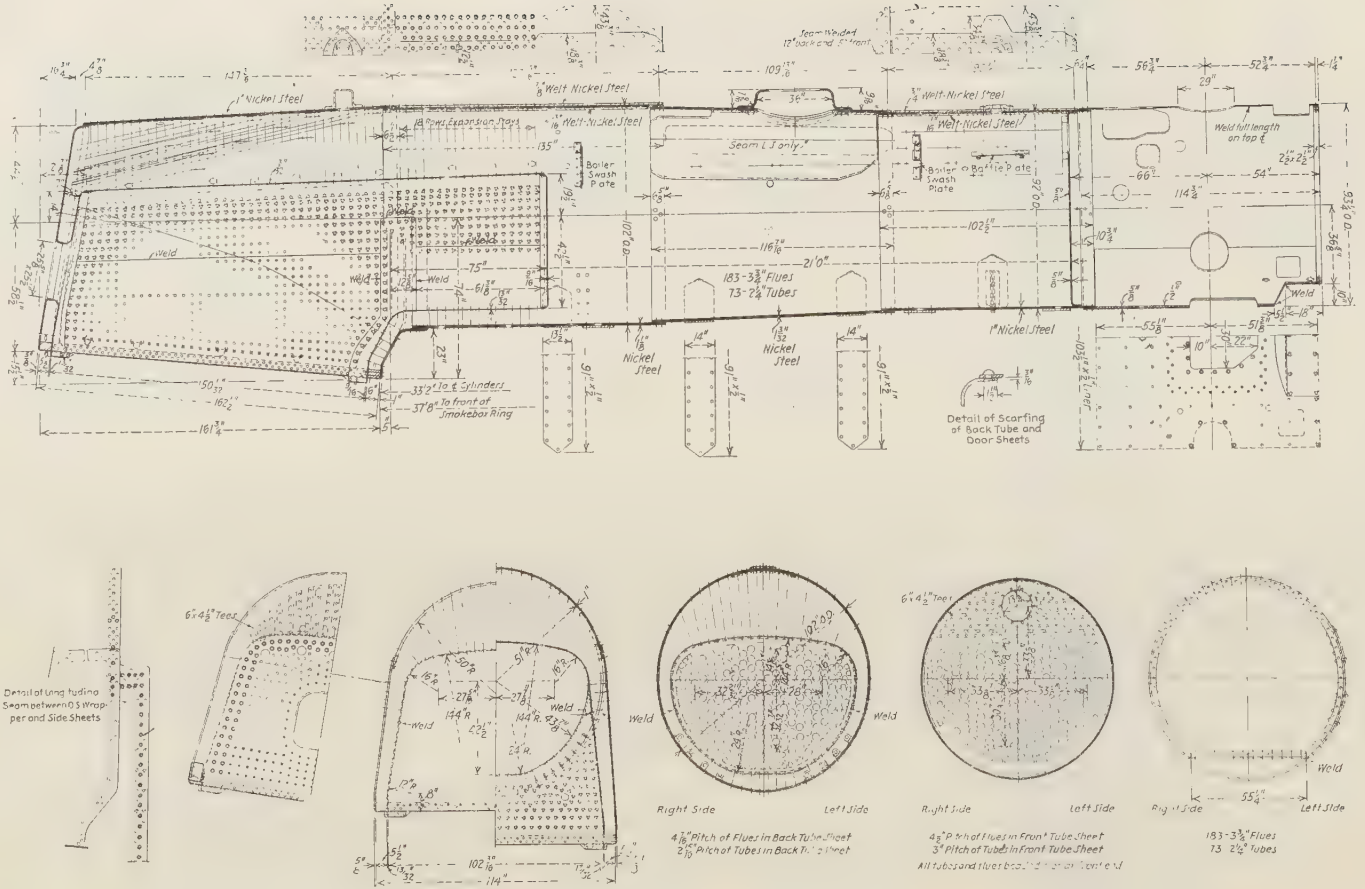

1" Nickel Steel
⅜" Welt Nickel Steel
Seam Welded 12" back and 6" front
Seam L.J only
Boiler Swash Plate
Boiler Baffle Plate
Weld full length on top ℄
Weld
183-3⅜" Flues
73-2¼" Tubes
21'0"
Nickel Steel
Detail of Scarfing at Back Tube and Door Sheets
33'2" to ℄ Cylinders
37'6" to front of Smokebox Ring
Detail of Long'tudina Seam between Outside Wrapper and Side Sheets
6"-4½" Tees
Weld
Right Side
Left Side
4 1/16" Pitch of Flues in Back Tube Sheet
2 7/16" Pitch of Tubes in Back Tube Sheet
4 9/16" Pitch of Flues in Front Tube Sheet
3" Pitch of Tubes in Front Tube Sheet
All Tubes and Flues Brazed Over Entire End
183-3⅜" Flues
73-2¼" Tubes

Fig. 3. — Elevation and cross-sections of the boiler of the K. C. S. 2-10-4 type freight locomotive.

thickness of the nickel-steel shell in the three courses is 1 in., 1 3/32 in. and 1 1/8 in., respectively.

The firebox is provided with a combustion chamber which extends forward into the boiler 75 in. The distance from the top of the crown sheet at the front and the inside of the wrapper sheet is 29-31/32 in., thus providing more than usual steam space over the firebox.

The side sheets, crown sheet, combustion chamber and inside throat sheet are welded. The inside door sheet and the tube sheet are riveted in place. The calking edge of the former, however, is welded up 36 in. from the mud ring and all inside and outside firebox sheets are welded at the calking edges around the mud ring. Calking edges of all seams adjacent to flexible staybolt sleeves are also welded. In the construction of the shell the longitudinal seam of the first course is seal welded 12 in. at the back and 15 in. at the front.

The combustion chamber is fitted with a complete installation of flexible staybolts as are also at the top, ends and upper corners of the side sheets. The coal-burning locomotives are equipped with Standard BK stokers and Firebar grates. They are fitted with ash pans of unusually large capacity.

The boilers include the type E superheater, the units of which are installed in No. 10 BWG tubes of 3 3/4 in. outside diameter — one of the first, if not the first, installation of tubes of this size. The superheater header includes the American multiple type throttle valve with a maximum lift of 1 3/4 in. The drypipe is fitted with a Tangential steam dryer.

All of the locomotives are fitted with the Worthington type 6 feedwater heater. The heater is mounted in the top of the smokebox and the exhaust pipe from the cylinder to the feedwater heater is attached directly to the cy-

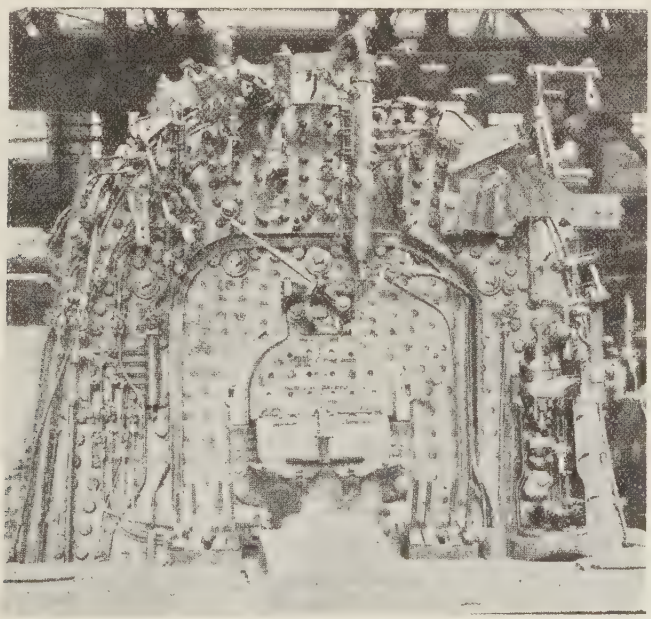


Fig. 4. — Back head of one of the coal-burning locomotives, showing the arrangement of piping under the jacket.

linder inside the smokebox. The hot-water feed pump is located ahead of the cylinder saddle under the smokebox and is rigidly mounted on the bed casting. The hot-water line is designed to have a direct head of water from the heater to the pump. Where it emerges from the smokebox a single elbow casting connects it with the pump.

The water is delivered to the boiler through a top check. Under the check are baffle plates which break up the entering stream of water. Back of the check is a transverse swash plate and just in front of the back tube sheet is another. The boiler is equipped with the Model C Gunderson process apparatus for boiler-water treatment.

The smokebox on the oil-burning locomotives is based on the railroad's standard type of exhaust nozzle with Venturi gas nozzle. No netting or deflector plates are used.

The foundation of the locomotive is a General Steel Castings bed casting, of which the cylinders and back cylinder heads are an integral part. This casting also includes the main reservoir. The

General dimensions, weights and proportions of the K. C. S. 2-10-4 type locomotives

	Coal-burning	Oil-burning
Railroad	K. C. S.	K. C. S.
Builder	Lima	Lima
Type of locomotive	2-10-4	2-10-4
Road class	J	J
Road numbers	905-909	900-904
Date built	1937	1937
Service	Freight	Freight
Dimensions:		
Height to top of stack, ft. and in.	16-0	16-0
Height to center of boiler, ft. and in.	10-10 1/2	10-10 1/2
Width overall, ft. and in.	11-4	11-4
Length overall, ft. and in.	111-4 1/8	111-4 1/8
Cylinder centers, in.	95	95
Weights in working order, lb.:		
On drivers	353 300	350 000
On front truck	51 500	50 600
On trailing truck	109 200	108 400
Total engine	514 000	509 000
Tender	359 690	348 000
Wheel bases, ft. and in.:		
Driving	24-4	24-4
Rigid	6-1	6-1
Engine, total	48-8	48-8
Engine and tender, total	98-5	98-5
Wheels, diameter outside tires, in.:		
Driving	70	70
Front truck	42	42
Trailing truck	42	42
Engine:		
Cylinders, number, diameter, stroke, in.	2-27 × 34	2-27 × 34
Valve gear, type	Walschaerts	Walschaerts
Valves, piston type, size, in.	14	14
Maximum travel, in.	7 1/2	7 1/2
Steam lap, in.	1 5/16	1 5/16
Exhaust clearance, in.	1/8	1/8
Lead, in.	1/4	1/4
Cut-off in full gear, per cent	85	85

Boiler:		
Type	Conical	Conical
Steam pressure, lb. per sq. in.	310	310
Diameter, first ring, inside, in.	90	90
Diameter, largest, outside, in.	102	102
Firebox, length, in.	150	150
Firebox, width, in.	102 1/8	102 1/8
Height mud ring to crown sheet, back, in.	72 1/2	72 1/2
Combustion chamber length, in.	75	75
Arch tubes, number and diam., in.	5-3 1/2	5-3 1/2
Tubes, number and diam., in.	73-2 1/4	73-2 1/4
Flues, number and diam., in.	183-3 3/4	183-3 3/4
Length over tube sheets, ft. and in.	21-0	21-0
Fuel	Soft coal	Oil
Stoker	Standard BK	...
Grate type	Firebar	...
Grate area, sq. ft.	107	107
Heating surfaces, sq. ft.:		
Firebox and comb. chamber	446	446
Arch tubes	54	54
Firebox, total	500	500
Tubes and flues	4 654	4 654
Evaporative, total	5 154	5 154
Superheating	2 075	2 075
Comb. evap. and superheat.	7 229	7 229
Feedwater heater, type	Worthington	Worthington
Tender:		
Type	Rectangular	Rectangular
Water capacity, U. S. gal.	20 700	21 000
Fuel capacity	25 tons	4 500 gal.
Trucks	6-wheel	6-wheel
Journals, diam. in.	6 1/2	6 1/2
General data, estimated:		
Rated tractive force, engine, 85 per cent, lb.	93 300	93 300
Weight proportions:		
Weight on drivers ÷ weight, engine per cent	68.8	68.8
Weight on drivers ÷ tractive force	3.79	3.75
Weight of engine ÷ comb. heat. surface	71.2	70.5
Boiler proportions:		
Firebox heat. surface, per cent comb. heat. surface	6.9	6.9
Tube-flue heat. surface, per cent comb. heat. surface	64.5	64.5
Superheat. surface, per cent comb. heat. surface	28.6	28.6
Firebox heat. surface ÷ grate area	4.6	4.6
Tube-flue heat. surface ÷ grate area	43.5	43.5
Superheat. surface ÷ grate area	19.4	19.4
Comb. heat surface ÷ grate area	67.5	67.5
Tractive force ÷ grate area	871	871
Tractive force ÷ comb. heat. surface	12.9	12.9
Tractive force × diam. drivers ÷ comb. heat. surface	903.4	903.4

front bumper, however, is cast separately. There are four waist sheets, all of which have sliding fits on the boiler.

The cylinders are 27 in. by 34 in. and are fitted with three-step bushings of Hunt-Spiller gun iron. The same material is used in the valve bushings. The steel pistons and the valves are both fitted with Hunt-Spiller gun-iron bull rings and Duplex sectional packing rings.

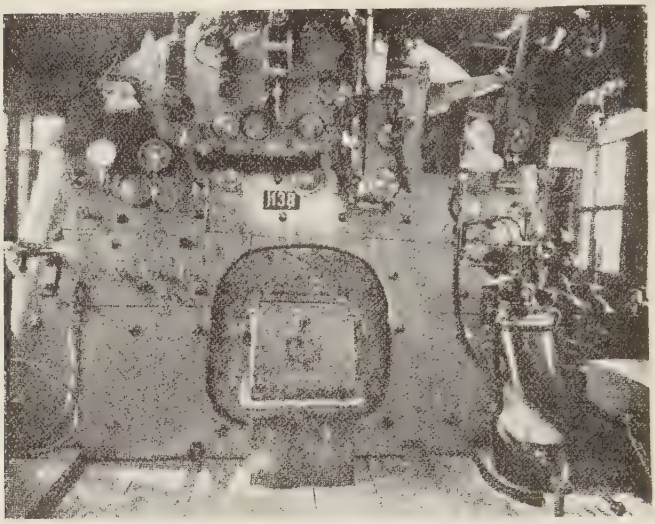


Fig. 5. — The finished back head of one of the oil-burning locomotives.

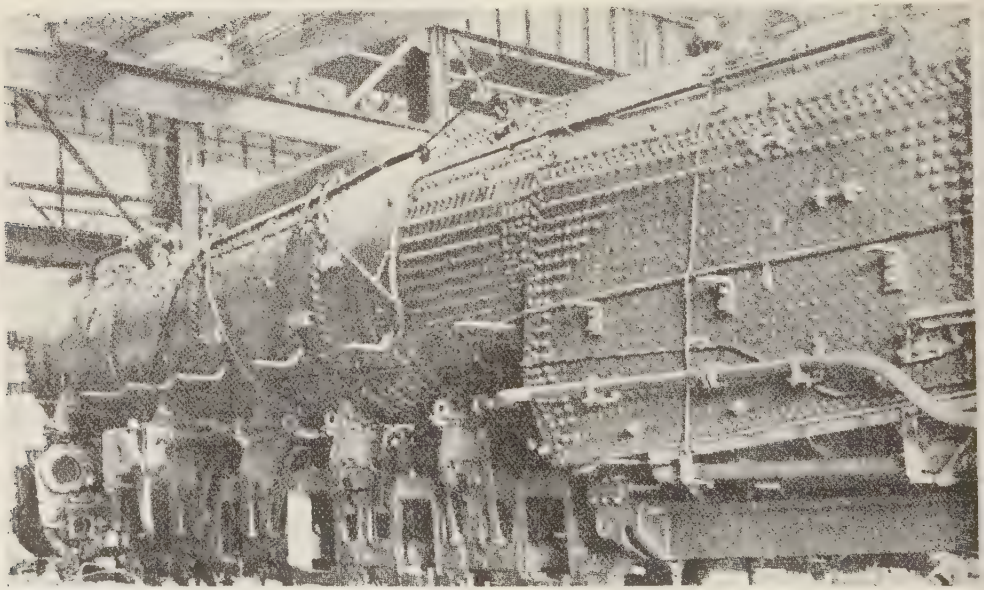


Fig. 6. — A locomotive in the erecting shop before the application of lagging to the boiler.

The driving wheels are 70 in. in diameter and are of the Boxpok type. The main journal bearings are fitted with SKF roller-bearing boxes, with journals 13.7845 in. in diameter by 14 1/2 in. long. All other journals have crown bearings 11 1/2 in. in diameter by 14 in. long. The first, second and fifth pairs of driving wheels are fitted with lateral-motion driving boxes.

The two-wheel engine truck is of the inside-bearing type and the four-wheel trailer truck is of the Delta type, both furnished by the General Steel Castings Corporation. The engine-truck journals are fitted with SKF roller-bearing journal boxes. While the trailer-truck journals now have plain bearings, the trucks are designed with a view to the future application of roller-bearing boxes.

The guides and crossheads are of the multiple-bearing type. The locomotives are fitted with the Tandem type of main rod driving on the third and fourth pairs of wheels. The cylinder centers have a spread of 95 in.

Equalization is broken between the third and fourth pairs of drivers. The first three pairs are cross-equalized with the two-wheel engine truck and the fourth and fifth pairs separately equalized on each side with the trailing truck. The spring hangers are of the stirrup type.

The locomotives are fitted with the Walschaerts valve motion with a link of skeleton type construction. The maximum travel of the valve is 7 1/4 in. Franklin type B reverse gears are used.

Force-feed lubrication is provided for all driving-box hub faces, shoes and wedges, in addition to the usual feeds for cylinders, valves and guides. Detroit force-feed lubricators are fitted. Individual mechanical lubricators are provided for each air compressor.

The brakes are Westinghouse Schedule 8-ET and include two 8 1/2-in. cross-compound air compressors which are mounted in front of the smokebox on the engine bed. The driver brakes on this locomotive are operated by five 12-in. by 10-in. cylinders. Two driver-brake cylinders, placed side by side on the guide yoke, operate the brakes on the first and second pairs of drivers and there is a separate brake cylinder for each of the third, fourth and fifth pairs of driving wheels.

Although no special cowling has been employed on these locomotives, they present an exceptionally neat appearance. Not only does this apply to the exterior of the locomotives, but also to the back heads within the cab as well. Here the arrangement of the piping under the jacket and the employment of a pedestal type brake valve conceals the usual confusion of piping in the locomotive cab. There are two sand boxes, one in front of and the other at the rear of the steam dome. They are combined with the steam-dome casing in a single structure. The locomotives are fitted with vestibule cabs.

The tenders have been built as large as possible within the limits of maximum axle loads for six-wheel trucks. The coal-burning tenders have a capacity of 20 700 gallons of water and 25 tons of coal and weigh, loaded, 348 000 lb. They are built up of Cor-Ten steel on the General Steel Castings water-bottom type underframe. The tenders are carried on Buckeye trucks which are fitted with SKF roller-bearing journal boxes. The trucks are fitted with Simplex unit-cylinder clasp brakes.

The general dimensions, weights and proportions of these locomotives are given in the table.

[621.335 (.45) & 621.338 (.45)]

The Breda 900-H.P. electric streamline trains.

(Engineering.)

Traffic conditions in many parts of Italy are particularly favourable for the use of high-speed railcars, and a number of such cars are already in use, while other interesting designs are under construction. Last year the Italian State Railways ordered six electric streamlined trains from the *Società Italiana Ernesto Breda,* Milan, and nine oil-engined streamlined trains from Messrs. *Fiat.* The *Breda* trains consist of three articulated units, giving a total length of 62.8 m. (206 ft.), while the *Fiat* trains also consist of three articulated units, but with a total length of 60 m. (197 ft.). More recently, an order has been placed with the *Fiat* Company for 22 electric railcars, 26 m. (85 ft.) in length, and an articulated oil-engined car 42.5 m. (140 ft.) in length. All these units have a service speed in excess of 135 km. (84 miles) per hour.

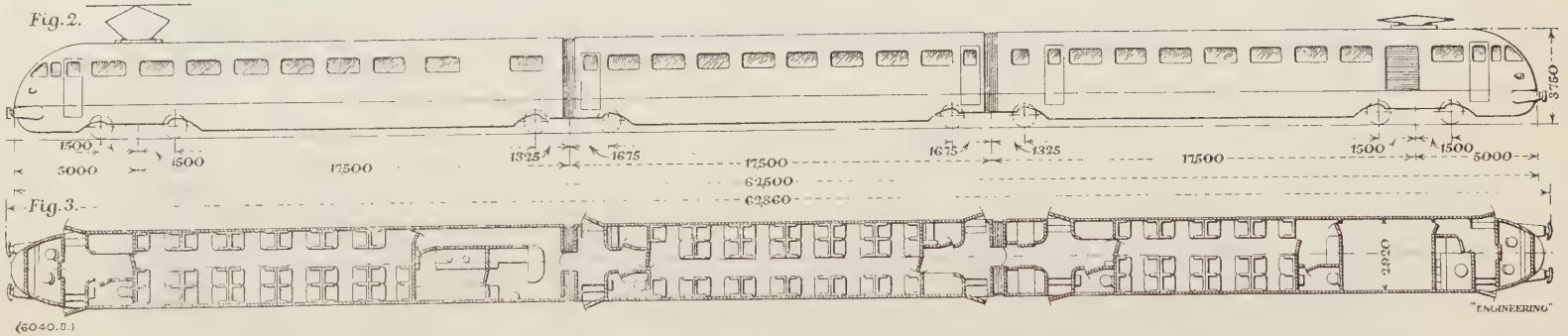
In this article, we propose to deal more specifically with the *Breda* electric streamlined train, which is now in operation between Naples and Bologna. The train carries first- and second-class passengers, and leaves Naples daily at 10.10 a. m. It reaches Rome at 12.15 p. m., covering the distance of 214 km. (134 miles) without a stop at an average speed of 102 km. (64 miles) per hour. The train leaves Rome at 12.25 p. m., and arrives at Florence at 3.35 p. m., covering the 319 km. (200 miles) in 3 hours 10 minutes at an average speed of 101 km. (63.1 miles) per hour. Finally, it leaves Florence at 3.40 p. m. and arrives at Bologna at 4.35 p. m., covering the 97 km. (60.6 miles) in 55 minutes at an average speed of 106 km. (66.2 miles) per hour. The timing on the return trip is identical. The whole journey from Naples to Bologna thus occupies 6 hours 35 minutes, against the previous service timing of 8 hours 5 minutes. The train is illustrated in Figures 1 to 10 and consists of two power coaches, each 22.5 m. (73.8 ft.) long, and an intermediate coach 17.5 m. (59.4 ft.) long. The overall length is thus 62.5 m. (205 ft.), while the length over the buffers, as already stated, is 62.8 m. (206 ft.). The maximum width is 2.92 m. (9.5 ft.) and the maximum height 3.75 m. (12.3 ft.) measured to the top of the roof. The three coaches are carried on four 4-wheeled bogies as shown in Figures 1 and 2, the intermediate bogies carrying one end of the intermediate and outer coaches as shown. The intermediate coach is joined up to the outer coaches by bellows. The weight of the complete train in working order, but without passengers, is 105 tons. The electrical equipment is designed for continuous-current operation at 3 000 volts, and is controlled by pneumatically-operated contactors. The various units are operated by compressed air through the medium of electro-pneumatic valves operating on a low-tension circuit. The control desks at each end of the train are exceedingly compact, and are provided with two handwheels, a detachable wheel for reversing, and a fixed wheel for forward control. The two controls are interlocked in the usual manner. The forward controller has a zero position, a starting position with all the resistances inserted and the motors in series, and a number of other positions corresponding to various train speeds. A special acceleration relay, an automatic starting regulator with elec-

tro-pneumatic control, and automatic interlocks ensure the automatic cutting-out of the starting resistances and the correct order of opening and closing the circuits, so that any possibility of incorrect operation is avoided. The automatic regulator referred to is controlled by the accelerating relays which can be operated in conformity with the various values of the maximum current required for acceleration, and provides for the possibility of hand control, in a similar manner to an ordinary control desk. There are six traction motors in all, having a total power of 900 h. p., there being two on each of the outer bogies and one on each of the inner bogies.

There is seating accommodation for 94 passengers, arranged as shown in Figure 3. The accommodation consists of 35 seats for second-class passengers in the first coach, 35 seats for first-class passengers in the second coach, and 24 seats for second-class passengers in the third coach. Each coach is provided with a compartment for heavy luggage in addition to the usual light luggage racks. In addition to the driver's compartment, the first coach contains a kitchen for the service of the whole of the passengers throughout the train. The second coach contains accommodation for the kitchen and train staff, and the third coach, in addition to the second driver's compartment, contains a subsidiary kitchen with storage room for wines and minerals, a freight room with a capacity of 3 tons, and a compartment for postal services. An equivalent train of the usual type, composed of a locomotive, guard's van, two passenger coaches, a postal van and a restaurant car, would weigh about 300 tons, or nearly three times that of the electric train.

As will be seen from Figures 1, 2 and 8, apart from the aerodynamic form of the front, the wind resistance of the underside of the train has been given careful attention, and all avoidable projections have been eliminated throughout the length. The sides of the coaches converge slightly towards the roof and are perfectly smooth; the windows, with the exception of those serving the kitchens, are of the fixed glass type, and are almost flush with the outer surface of the coach bodies to eliminate eddy currents so far as possible. The bellows between the coaches are of the same cross section as the bodies, to avoid re-entrant angles at these points. The only appreciable projections are the emergency lamp brackets on the roof, the door steps, the hand grips and door locks, the gutters above the doors, the hooks for the route indicator on the front, the buffers, and the pantographs. To reduce the resistance of the latter as far as possible, they are built of tubular steel of approximately elliptical section. Each coach is fitted with air conditioning plant, consisting of a filter through which the air in circulation is passed, a fan of sufficient size to ensure 20 to 25 complete changes of air per hour, a heating system composed of electric resistances for winter conditions, and an air cooling and humidifying plant for use in summer. All the conditioning plant is located below floor level, and is covered by the underplating of the body, which descends to within 250 mm. (9 13/16 in.) from the rails. The various units are separated by cross divisions forming a series of compartments to which access for inspection and maintenance is given by doors formed in the under surfaces of the coaches. Several of the compartments have their own system of ventilation to avoid unfavourable conditions arising from the heat given off by the starting resistances, or excessive ionisation of the air resulting from the electric discharges of the electro-pneumatic contactors. The main air inlets to the air conditioning plant can be clearly seen in Figure 1 on the first coach. The inlet is on the same side on the third coach, and on the opposite side on the second coach.

Fig. 1. — The complete train.



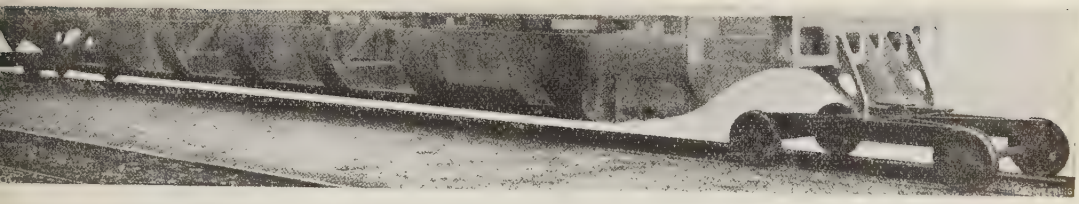


Fig. 6. — Lower portion of coach showing side compartments.

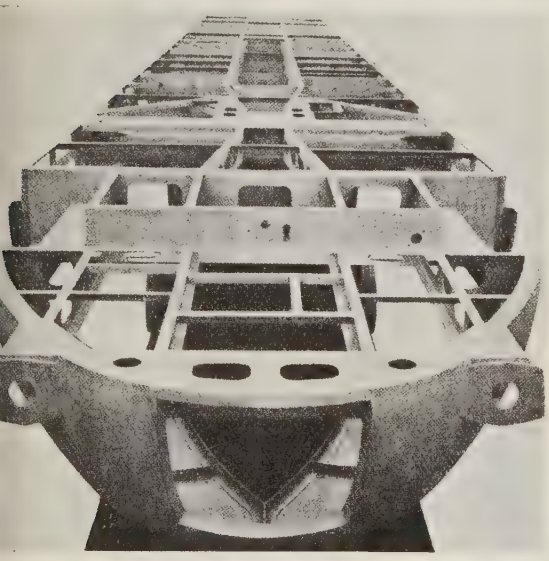


Fig. 7. — End view of lower portion of coach.

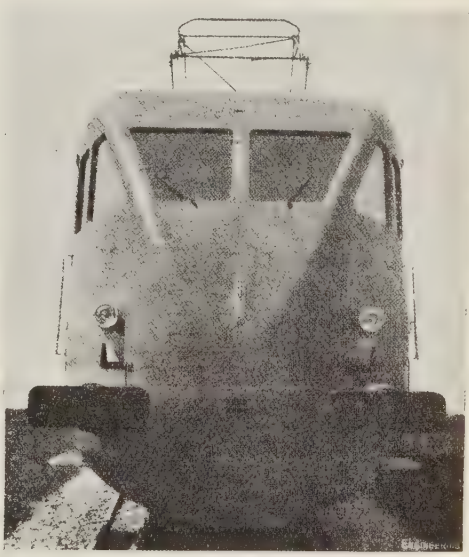


Fig. 8. — Front view of completed train.

Turning now to the constructional details, one of the two outer bogies, equipped with two traction motors, is illustrated in Figure 4. The axle bearings are of the roller type, and the axles are of chrome-nickel-molybdenum steel with a tensile strength of 90 kgr. per mm² (54 tons per square inch) and a minimum elongation of 12 per cent. The wheels are 1 m. (3.28 ft.) in diameter, the wheelbase is 3 m. (9.84 ft.), and the weight of the bogie completely equipped is 1 175 kgr. (2 585 lb.). The power from the motors is transmitted to the wheels by a flexible transmission consisting of hollow shafts coupled to the wheels by laminated springs. The suspension of the bogie frame is of the usual type, consisting of a combination of leaf springs and helical springs as shown, and the oscillating beam on which the body rests is carried on inverted leaf springs. To damp out vibrations at high speed as much as possible, the various metal components of the suspension are separated by rubber pads. The openings into which the air is drawn for the ventilation of the motors are clearly visible in Figure 4. The air ducts are connected to the motors by joints of the bellows type, as shown, and register at their upper ends with openings in two trunks formed in the body

understructure, the air being drawn into the trunks at a point where it is relatively free from vortices and where there is little dust. The inner bogies, one of which is illustrated in Figure 5, are of the same general dimensions as the outer bogies, and have the same wheelbase. As already stated, they are provided with only one traction motor, and the oscillating beam on which the body is carried is not located centrally between the axles, as in the outer bogies, but is nearer to the non-driven axle. The weight of the inner bogies is 8 650 kgr. (19 030 lb.), including the motor. Both bogies are equipped with pneumatic brakes operating on all four wheels, and in addition, the outer bogies only are equipped with hand brakes. The brake rigging can be seen on both bogies in the photographs reproduced in Figures 4 and 5, and it will be noticed from Figure 4 that the hand gear is operated by a horizontal shaft terminating in a sprocket. This sprocket engages with a gear wheel keyed to a shaft provided with a right- and left-handed thread, and the nuts on this shaft are coupled to the upper ends of the brake levers by slotted links, the levers sliding through the slots when the pneumatic brakes are operated. It may be mentioned that the air pipes to the brake cylinders are provided with a relief valve controlled by an electro-pneumatic relay. A mercury interrupter of the centrifugal type is inserted in the electric circuit, and so long as the speed of the train is maintained in excess of about 45 km. (27 miles) per hour, the interrupter remains closed, and maximum pressure can be maintained in the brake cylinders. Should the speed fall below this value, the interrupter opens and, in turn, allows the relief valve to open sufficiently to prevent the wheels being locked.

The construction of the coach bodies, illustrated in Figures 6 to 10, is of exceptional interest. The basic principle of the design has been to secure an approximately tubular structure, which was considered the most suitable form to resist the superimposed stresses with a minimum of weight. The principal function of the structure is to act as a beam spanning the bogies, but in designing this beam, consideration had to be given to its subsidiary functions, such as accommodating the auxiliary apparatus mounted on the coach in the most convenient manner, and forming the base for the floor of the coach. These subsidiary functions largely determined the form taken by each of the components constituting the complete structure. Five principal considerations were involved in the design : the weight, the cost of the materials employed and of their fabrication, durability, facilities for carrying out repairs, and facilities for carrying out the necessary train servicing. Two types of steel were employed in the structure, either in sheet or profile form, both having a tensile strength of 45 kgr. to 50 kgr. per square mm. (27 tons to 30 tons per square inch). One steel has, however, an elongation of 16 per cent. to 18 per cent. and the other an elongation of 20 per cent. to 23 per cent., the higher material being employed for those members which, on account of their form, had to be worked cold. In general, the stresses to which every member of the structure would be subjected were carefully worked out with a view to reducing the weight to a minimum without the sacrifice of safety. Electric welding was employed throughout in building up the body, arc welding being used, with a few exceptions rendered necessary by questions of assembly, for uniting the profile sections, and resistance welding for uniting the panels to the main structure. The whole body can be considered as being made up of four principal elements, comprising the frame, the external sides and the roof, and subsidiary elements comprising the transverse divisions and internal

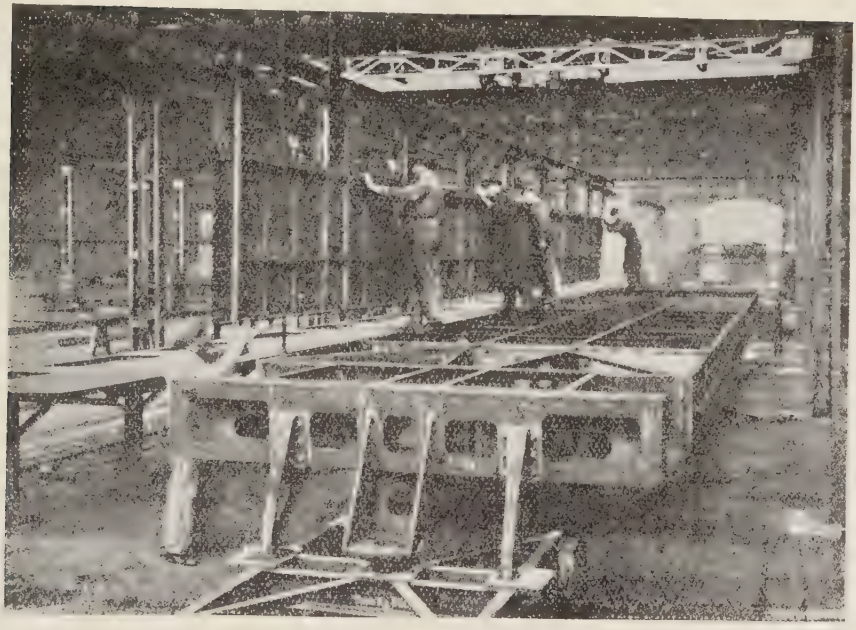


Fig. 9. — Frame of end coach.

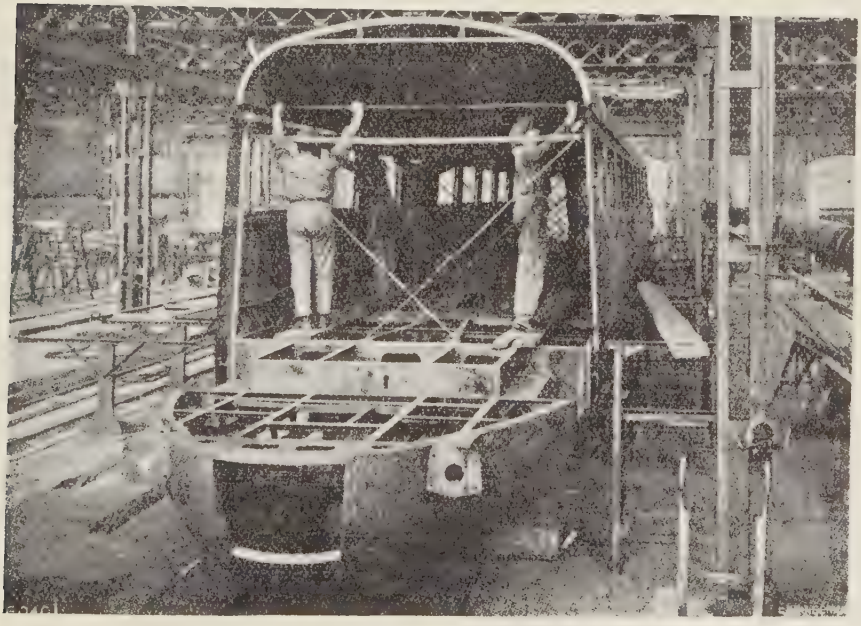


Fig. 10. — Assembly of sides and roof.

sides, and the flooring. As will be clear from Figures 7 and 9, which show the construction of one of the outer coaches, the frame is composed of four main longitudinal members of considerable depth, consisting of two inner and two outer members. The sides of the coach are attached to the outer longitudinals, as shown in Figure 9, and the inner and outer longitudinals on each side are bridged by a series of cross members, as shown in Figure 7. The cross members form the supports for the floor of the coach. At the front end of the frame, shown in Figure 9, the inner longitudinals are extended at a lower level to line up with the cross beam which carries the brackets resting on the outer bogie. The beam is hollow, and serves as a reservoir for the compressed air necessary for operating the brakes and for other services. This beam cannot be seen in Figure 9, as it is too far back. The front of the coach has a considerable overhang over the bogie, as shown in Figure 1. It will be observed from Figure 6 that the arrangement of the brackets resting on the bogie is different at the two ends, due to this overhang in the one case. The brackets at the left-hand end in this illustration, that is at the front end of the coach, cannot be clearly seen, but it will be observed that the two outer brackets are formed in the outer plating. The inner bracket is welded on to the beam referred to in a somewhat similar manner to the bracket at the opposite end of the coach, although, as stated, the beam is lower at the leading end. As the continuity of the frame is interrupted beyond this point, the structure forming the stairway, shown in Figure 10, in front of the side walls, is of very strong section. Beyond the beam, the outer longitudinals are extended and terminate in the buffer brackets, the inner longitudinals being also extended and widened out to form a compartment in which are located electric and pneumatic couplings for use in the event of additional coaches being attached to the train. The opening giving access to these couplers, clearly visible in Figure 7, is normally closed by a door, as shown in Figure 8. The form of the underplating is clearly shown in Figure 6, and this view also shows the rear-end structure, with the brackets, which extend down through the framework of the inner bogie and rest on the oscillating beam already referred to. The brackets can be seen more clearly in Figure 9, which also shows the rear end of the frame. It will be observed that there are three brackets, of which the two outer brackets, of cast-steel, are riveted to the end beam of the frame. The central bracket, of fabricated steel, is welded to the end beam. This bracket is coupled to the oscillating beam of the bogie, through a pivot bearing, through which the tractive effort is transmitted, while the two outer brackets make contact with the beam through the medium of bronze shoes. Both ends of the frame of the intermediate coach are generally similar to the inner end of the frames of the outer coaches, the centre brackets being narrower to enter the space between the webs of the brackets on the outer coach frames, so that both coaches can pivot on the same pin, and the two outer brackets at each end being closer together, so that their feet can rest on the oscillating beams between the outer brackets on the end coaches. The form of the coach sides can be seen in Figure 10. The framing is made up of light steel members, made from folded 3-mm. plate, welded together. The outer plating is 1.5 mm. in thickness, and is welded to the framework at numerous points. Each side is about 15 m. (52.2 ft.) long by 2 m. (6.56 ft.) high, and weighs 765 kgr. (1 683 lb.). The form of the roof can also be seen in Figure 10, as well as in Figures 1 and 2. The portion

of constant section, seen in Figure 9, has a length of about 19 m. (62.3 ft.), and weighs 1 240 kgr. (2 728 lb.). As in the case of the carriage sides, the roof consists of plating welded to a framework made up of light folded steel members.

On completion, the coaches composing the train were subjected to static loading, equivalent to the full service and passenger loading, plus six persons standing per superficial square metre. With this loading, the maximum deflection of the framework was only 8 mm. (5/16 in.), and on removal of the load, the structure returned to its original form. On the subsequent trial run, a maximum speed of 175 km. (109.3 miles) per hour was attained. At a later date, on a trial made with a view to studying the effect of high speeds on the train and permanent way, a maximum speed of 192 km. (120 miles) per hour was reached.

NEW BOOKS AND PUBLICATIONS.

[625 (02)]

CORINI (Felice). Engineer, Professor at the University of Genoa. — **Scienza e tecnica delle costruzioni stradali** — Tracciato — Corpo stradali — Sovrastrutture — Gallerie (*Science and practice of highway construction* — Location, Formation, Superstructure, Tunnels). Vol. I. — One volume (7 × 9 7/8 in.), of 856 pages, with numerous diagrams and 16 folding plates. — 1937, Milan; Ulrico Hoepli, publisher.

In 1937, Signor Felice CORINI, Engineer, and Professor at the University of Genoa, published through Ulrico Hoepli, of Milan, the first volume of a treatise on highways, comprising both roads and railways.

This work is entitled : *Scienza e tecnica delle costruzioni stradali* and will be in two volumes.

The *first,* now published, deals with the *preparation and development of the scheme,* and will be briefly reviewed in the course of this notice. The second volume will deal with practice, and the carrying out of the scheme.

We would like to stress from the outset the scientific nature of this treatise. Reading it we feel that, in Professor CORINI, the engineer is also an experienced mathematician, accustomed to recognising the strong and weak points of a theory, and defining the practical limits of a formula.

The introduction of mechanical traction has, he states, completely revolutionised road construction and surfacing. In recent years the weights of vehicles have greatly increased; in place of the single vehicles of the past, we now have powerful tractors with trailers. Speeds have reached figures equal to or even greater than those on the railways.

In the past, roads were constructed exclusively for animal traction and motor traffic had to make shift with what existed.

The old roads, however, no longer meet the requirements of present-day traffic; they are as obsolete from the point of view of alignment and profile as that of pavement.

A treatise on roads can no longer be a mere description; it should also state the scientific problems which arise and have to be dealt with. « That is why », says Professor CORINI, « I have entitled my work : The Science and Practice of Highway Construction ».

Volume I deals, as we have said, with the preparation and development of the scheme, and is divided into five parts.

The first part comprises : an introduction to the study of highways, the history and evolution of the road, and a very full account of the general principles to be taken into account in preparing a scheme for a road or railway. The whole of the first chapter is devoted to the topographical work, surveying, the study of maps, the modern method of photographic aerial surveying, and the plotting of contour lines.

The second part deals with the detailed determination of the location, and the limiting radii and gradients, and is particularly interesting by reason of the scientific and original nature of the notes on the mechanisation of transport.

In view of the enormous growth of motoring in every country of the world, and the ceaseless extension of motor roads, a special chapter is, very reasonably, devoted to the behaviour of an automobile in motion, especially on curves and transitions.

In the course of this second part,

Signor Corini has taken care to stress the economic aspect of the computation of the minimum radius and maximum gradient, with a view to reducing maintenance costs, without unduly increasing the first cost.

The third part deals with the cubing of earthwork, the earthwork itself, and with structures : culverts, bridges, viaducts, and retaining walls. It includes some interesting and important matter relating to graphical and mechanical methods of estimating earthwork quantities.

The question of bridges, says Signor Corini, is of such importance that it deserves a special work to itself. In dealing with it, the Author has kept prominently in view the close connection which exists between the layout of a road- or railway, and the selection of the structures, such as location of the bridges in plan and elevation, type of construction to be adopted, clearance to be provided, etc.

The fourth part is entirely concerned with tunnels, which are very fully dealt with.

The chapter, in which linings are subjected to critical study and theoretical discussion, is worth particular attention.

Finally, in the fifth and last part of the first volume, under the heading « Superstructure », Signor Corini describes the various types of modern roadways, devoting several chapters to monolithic and plastic construction, to oil-surfacing agents, to the concrete road, and special surfacing materials. This account is preceded by mathematical considerations about the vibrations to which neighbouring buildings, etc., are subjected by road traffic.

* * *

Volume II, announces Professor Corini, will consist of four parts dealing with the carrying out of the scheme. The earthwork — excavation, transport and filling — erection of structures, including the all-important question of foundations; in a word, the creation of all but the actual track of a road or railway, will be studied in the first part.

Modern methods of earth excavating, the use of machinery, drills and explosives for rock cutting, will also be specially studied.

Among the various designs of foundations of structures, the Author proposes to deal at some length with foundation work under compressed air.

The whole of the second part of the work will deal with the construction of tunnels : determination of the centre-line, organisation of the work, methods of driving, removal of spoil, and lining.

The third part will deal with the various types of highways.

Finally, in the fourth part, the Author will examine the financial and economic sides of the problem, taking into account the various laws and regulations to be complied with in connection with the tendering out and the execution of public works.

It is evident that Professor Corini has endeavoured, in this treatise, to approach and explore every question bearing on the vast subject of roads. As he himself remarks, he endeavours to deal with this problem *con mentalita moderna.* He does not confine himself to mere descriptions, nor does he avoid difficult questions; quite on the contrary, he draws the attention of the reader to the need for further research.

* * *

The first volume, covering design, is clear and methodical, scientifically planned, and answers in every way to present day requirements.

[659 (.42)]

Facts about British Railways, 1938. — A pamphlet (6 1/2 × 4 inches) of 32 pages, with inset map. — Issued by the British Railways' Press Office, St. Ermin's (South Entrance), Caxton Street, Westminster S. W. 1, on behalf of the Great Western, London and North Eastern, London Midland & Scottish, and Southern Railway Companies. Free on application.

This small pamphlet gives a remarkably well thought-out review of the situation and work of the British railways in 1937.

Whether it is question of the financial position or of the operating results, the evolution of the traffic, the innovations introduced in passenger and goods services, or again of the part played by the Companies in the operation of other methods of transport, or the management of hotels and large harbours, the characteristic figures and most salient facts are clearly stressed. In the same way, as far as the rolling stock and equipment is concerned, information is given about the importance of the stock, the development of the lines, and new acquisitions or extensions. A few details about the volume of goods purchased shows the part played by the railways as customers of industry. The staff is not forgotten either; numbers, occupations, and corresponding expenditure under this heading are given.

On the first page, some of the records held are collected together, amongst them the long non-stop runs of the « Flying Scotsman » and « Royal Scot », as well as the fastest British trains. Another page lists the most striking innovations of the year, and it is not surprising to learn that this again begins and ends with train accelerations.

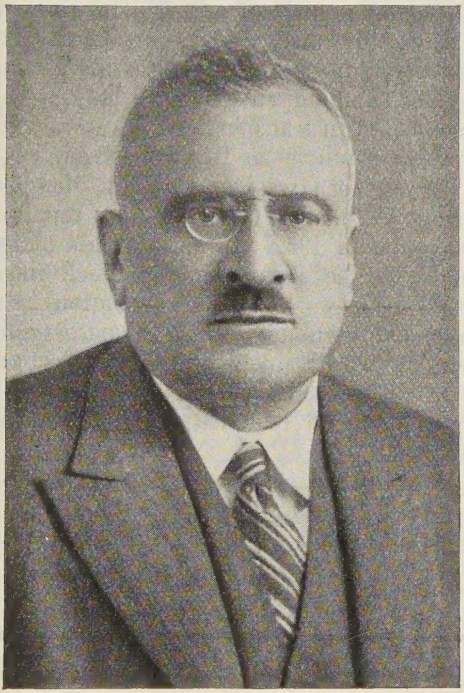
A well designed map shows the extent of the lines owned by the four Companies, those run over by the long-distance trains being accentuated. The large ports are shown, among the seaside towns served, together with the chief destinations of the sea routes to them.

E. M.

OBITUARY.

Dr. Robert HEROLD,

Former Manager of the IIIrd Division of the Swiss Federal Railways,
Former Member of the Permanent Commission of the International Railway Congress Association.



We heard with deep regret of the death, on April 11th, of Dr. Robert HEROLD, former Manager of the IIIrd Division of the Swiss Federal Railways.

Dr. HEROLD was born in 1879, in Paris, where he received his elementary education, after which he went to the Winterthur secondary school. He subsequently decided to study law and political science and followed courses at the Universities of Zurich, Leipzig, Berlin, and finally at Munich, where he took his Doctor's degree in 1902. He entered the service of the Swiss Federal Railways in the same year and became departmental secretary of the former Vth division, at St-Gall.

Two years later he was appointed secretary of the Board of Directors and the Executive Committee of the Bodensee-Toggenburg Railway, then under construction. In this capacity, he had to settle by himself all administrative, legal and financial questions. In 1916 and 1917, he took the measures made necessary by the transitional organisation which ultimately led this Company to work its system by itself. He became the Manager of the Company in 1917. Despite his absorbing functions, Dr. HEROLD still found time to do much work of a scientific caracter at that time. He also held a professorship at the University of Zurich where he lectured on railway law and operation.

In 1922, he succeeded the Manager of the Railway Division at the Federal Post and Railway Department. In these functions, he was entrusted with various important missions, amongst which that of

delegate of the Federal Council to the International Rhine Committee, delegate to the Advisory and Technical Committee on Communications and Transit of the League of Nations, to the International Simplon Commission, and the Swiss Higher Tourist Council. He also acted as Federal expert in connection with the completion of the Furka line in 1926.

Owing to his thorough knowledge of railway law and traffic matters, he was called on by the League of Nations, to draw up, in 1923 and 1924, in collaboration with a British specialist, a valuation report on the Austrian Federal Railways.

In 1926, the Federal Council appointed Dr. Herold as Manager of the IIIrd Division of the Federal Railways at Zurich. He held this post for ten years and constanly showed his great ability as organiser.

On January 1st, 1936, at the earnest request of his higher chiefs, he retired from the position of divisional Manager in order to investigate some important problems of a legal nature. At that time, the Federal Department had taken in hand the delicate task of reorganising the Federal Railways and the whole Swiss transport system. As this work entailed a revision of the railway legislation, the Head of the Department was in need of a capable and most experienced man, and Dr. Herold thus became the Councillor and expert of the Department in connection with the special problems. At the head of the Committee of Experts who assisted him in the revision of Swiss law on railways, he started this big task, the completion of which will take several years. Death put a stop to his brilliant activity.

Thanks to his long and fruitful railway career, his many works on legal and transport questions, as well as his distinguished individuality, he will long be remembered in transport circles, as well in foreign countries as in Switzerland.

Dr. Herold was appointed a Member of the Permanent Commission of our Association in 1922. In spite of his many activities, he always showed much interest in the work of our Association. He attended the London (1925) Congress and was a Vice-President of the 2nd Section (Locomotives and Rolling Stock) at that Session. He resigned his mandate in 1926.

We wish to convey our sincerest sympathy to his family.

The Executive Committee.